



UNIVERSITY *of*  
TASMANIA

**Skilling Students in Digital Technologies using Long-Distance Controlled  
Robots over the Internet**

**by Megan Hastie**

A thesis submitted in fulfilment of the requirements for the degree of  
Doctor of Education  
University of Tasmania

## Statement of Originality

This thesis contains no material that has been accepted for a degree or diploma by the University or any other institution, except by way of background information and duly acknowledged in the thesis, and to the best of the my knowledge and belief no material previously published or written by another person except where due acknowledgement is made in the text of the thesis, nor does the thesis contain any material that infringes copyright.

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The study was approved by the Tasmania Social Sciences Human Research Ethics Committee on 7 August 2014. The Ethics reference is: H14122.

In compliance with the National Health and Medical Research Council (NHMRC), Chapter 4.2: Children and Young People, the following items were addressed:

- Research Merit, specifically school approval by the Brisbane School of Distance Education (the researcher's workplace)
- Number of Participants
- Selection of Participants
- Recruitment of Participants
- Data Sources and Identifiability
- Procedures
- Disclosure and Consent
- Potential Benefits, Risks and Harms
- Monitoring
- Feedback
- Data Storage
- Declarations

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## **Abstract**

To meet the emerging challenges of this century and stay competitive in the international marketplace, it is important that Australian students develop the skills they need for digital futures. However, many Australian students cannot access digital technologies like robots due to prohibitive costs and the ‘tyranny of distance’ and this means Australia is at risk of being further left behind in our region and globally. To overcome the current trade deficit in Information Technology (IT) and a looming shortage of workers skilled in Information Communication Technologies (ICT), Australian students must engage in Science, Technology, Engineering and Mathematics (STEM) learning and robotics.

The aim of this study was to determine the learning impact of a Long Distance Control Robot (LDCR) system when used by Australian students who could not access or had limited access to a physical robot. The study investigated the use of the LDCR system with students (n=32) aged 9-12 years at an Australian school of distance education during 2014. Students lived in a range of rural and remote and metropolitan settings throughout Queensland. They used the LDCR system over the Internet to operate the robot that was located in Brisbane.

Three research questions were posed:

1. When students operate a robot, what are their perceptions of their learning?
2. What STEM skills do students learn through robots?
3. What complementary skills do students learn when they operate a robot remotely using a Long Distance Control Robot (LDCR) system?

Data were collected from student surveys, a blog and video recording transcripts. The data were then thematically analysed using a case study approach that included coding density and content analysis. The research established that when students learned to operate a robot remotely using a LDCR system, their perception of learning was highly positive, their STEM learning accelerated, and they developed complementary skills such as procedural knowledge, technical skills and metacognition. With the expectation that Australian students will learn using robots, this study provides a way forward at very low cost irrespective of physical location.

## Glossary of Terms, Acronyms and Abbreviations

3C	The Collaborative Cyber Community
A+ Education	An educational database
ABC	Australian Broadcasting Commission
ACARA	Australian Curriculum, Assessment and Reporting Authority
ACER	Australian Council for Educational Research
ATNF	Australian Telescope National Facility
Blackboard	The learning content management system provided by Education Queensland and used at BSDE
Blog or weblog	A discussion or informational site consisting of discrete entries or ‘posts’ that is published on the World Wide Web
Bluetooth signal	A wireless technology standard for exchanging data over short distances
BSDE	Brisbane School of Distance Education
CA	Cyber Asynchronous
CASS	CSIRO Astronomy and Space Science
CCD	Charged-Coupled Device
CME	Continuing Medical Education
COAG	Council of Australian Governments
Coding density	The frequency of descriptive and explanatory references made by students
Cognition	The act of thinking, perceiving, and understanding
CoI	Community of Inquiry
Complementary skills	Those skills in which students described the procedures involved in using the LDCR system, the technical skills required to operate the robot using the LDCR system, and student explanations of their learning, specifically metacognition, when operating the robot remotely using the LDCR system
CS	Cyber Synchronous
CSIRO	Commonwealth Scientific and Industrial Research Organization
Cyber synchronous teaching	Teaching that takes place in a cyber face-to-face environment in real time or synchronously
Cyberspace	The notional environment in which communication over computer networks occurs
DCR14	Acronym derived from Distance Control Robot 2014 and the nickname given to the Lego NXT robot used in the study

Digital Divide	The gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard to both their opportunities to access information and communication technologies (ICTs) and to their use of the Internet for a wide variety of activities
Educational robots	Robots used to teach students about robotics
e-learning	Learning that takes place as a result of experiences and interactions in an Internet environment
e-learning manager	The role associated with the management of technology enhanced learning (TEL)
ELIC	Early Literacy In-service Course
ESO	European Southern Observatory
HF	High Frequency radio service
ICT	Information Communication Technologies
Interactive synchronous whiteboard	An electronic whiteboard that enables participants in a cyber face-to-face environment to use text, drawing and graphics to interact with each other
Knowledge about cognitive tasks	The ‘what’ and ‘how’ of learning, as well as when and why students use various strategies, as proof of learning expertise
KTC	Kanazawa Technical College
LDCCR system	Long Distance Control Robot system
Learning Management System (LMS)	A piece of software that manages, analyses, and runs educational courses and training programs. Also included are student registration, curriculum management, skill & competency management, and reporting features
Likert-scale	A method of ascribing quantitative value to qualitative data, using a five to seven point scale, to make it amenable to statistical analysis
LOGO	A programming language
MIT	Massachusetts Institute of Technology
NASA	The National Aeronautics and Space Administration
NEA	National Education Agreement
Node	A collection of references about a specific theme, place, person or other area of interest that enable the answering of research questions
NSYSU	National Sun Yat-Sen University
OECD	The Organization for Economic Co-operation and Development
PA	Physical Asynchronous

PEARL project	Practical Experimentation by Accessible Remote Learning project
PS	Physical Synchronous
PULSE@Parkes project	The Parkes radio telescope located in New South Wales, Australia
Queensland DETE	Queensland Department of Education, Training and Employment
RATEP	Remote Area Teacher Education Project
Response rate	In survey research, the actual percentage of questionnaires completed and returned
RFDS	Royal Flying Doctor Service
Resident Medical Officer	A doctor working at a house officer level (intern, JHO or SHO). It can also be used to refer generically to all junior doctors (Medical Registrar, PHO, SHO, JHO or intern).
Robocube	Hardware conceptualized for robots competing in the small robots league of RoboCup, the Robot World Cup Soccer Initiative
RoboCup	Robot Soccer World Cup Championship for older participants
RoboCupJunior (RCJ)	Educational robotics competition for teams of students up to the age of 19 years
RoboParty	Robotic camp conducted in Portugal
Robot	Any automated machine programmed to perform specific mechanical functions in the manner of a human
Robotics	The conception, design, manufacture, and operation of robots
SAT	South Australian Telescope
SENSORS project	Science Engineering NASA Site of Remote Sensing
SOTA	School of the Air
STEM	Science, Technology, Engineering and Mathematics
STEM literacy	The ability to identify, apply, and integrate concepts from science, technology, engineering, and mathematics (STEM) to understand complex problems and to innovate to solve them
SyRoTek1 system	A multi-robot system using robots equipped with rich sensor equipment in a wide variety of scenarios
TEL	Technology Enhanced Learning
Telecommunications	Communication over a distance by cable, telegraph, telephone, or broadcasting
The Holistic Blended Cyber Model	A model in which physical face-to-face, cyber face-to-face and cyber asynchronous blended models are synthesized into one holistic blended-learning model



Themes	The coding of material according to common patterns and ideas
Tyranny of distance	A term ascribed to Australian historian Geoffrey Blainey (1966), that has come to define Australia's geographical distance from many parts of the world and encapsulated the often extreme isolation experienced by non-metropolitan, rural and remote sectors of Australia's small and widely distributed population
Video recordings	Used in this study as a research instrument for the gathering of numeric and textual data using Blackboard Collaborate to record student operation of the robot via the LDCR system
VoIP	Voice over Internet Protocol
VRTP	Virtual Real-Time Presentation
WaterBotics	Curriculum in which small groups of students in the United States were involved in the collaborative design, construction, testing, and redesign of underwater robots

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## **Chapter 1**

### **1.1 Introduction**

There are growing concerns about Australia's place in an increasingly competitive global marketplace. All indicators, from government, industry, education and the media, point to Australia being further left behind in our region and internationally (Australian Government, 2012; The Organization for Economic Co-operation and Development, OECD, 2013; ABC News, 2013). The perennial problems of distance together with a widely dispersed population have resulted in serious access and equity issues for many Australian students, families, and communities. Clearly, we need to find ways to ensure that all Australian students, irrespective of their physical location, can access the skills they need to adapt to a changing labour market and stay competitive in the global economy.

Australia needs more skilled workers and educators need to find smarter and faster ways to skill more students. A solution to the skilling of Australian students for the global workplace can be found, I believe, in the innovative application of the new digital technologies in education. Although this type of technological innovation may seem self-evident in the 'digital age', I have come to the conclusion that the uptake of new technologies in Australian education has been consistently slow, due in large part to entrenched parochialism that is a consequence of our geographical isolation (Hastie, Hung, Chen & Kinshuk, 2010; Hastie, Chen & Leeming, 2009). This type of delay in the uptake of new digital technologies is a serious impediment to our progress as a nation, and to the development of our human capital – our students.

### **1.2 Why distance matters**

While teaching in Far North Queensland in remote communities on Cape York Peninsula in the 1970s, I witnessed firsthand the barriers posed by geography and distance in accessing the most basic of public services and in exercising the rights and duties of citizenship in Australia. My experiences during the 1980s and 1990s, while implementing programs such as the Early Literacy In-service Course (ELIC) for teachers and the Remote Area Teacher Education Project (RATEP) for indigenous teacher trainees in isolated communities, demonstrated unequivocally the transformative effect of technology enhanced learning (TEL).

With the advent of the Internet in the mid-1990s, and while working for Queensland Health as a Research Officer in a Commonwealth Government funded Junior Doctor Training Program, I conducted a research study to train resident medical officers (RMOs) in the use of the Internet for clinical problem solving. Participants in this study were tertiary trained medical personnel aged twenty years and older. The introduction of the Internet to the study participants formed part of their Continuing Medical Education (CME) program. The findings from the study were presented at Yale University School of Medicine in 1997, winning a 'Best Free Paper Award'. While this CME study confirmed the use of innovative digital technological solutions in medical education, it also signalled the wider potential for the use of the Internet in education.

The findings from the successful introduction of the Internet as an educational tool in medical education in the mid-1990s formed the basis for a trial of cyber synchronous teaching and learning at Brisbane School of Distance Education (BSDE) that commenced in 2001. This

trial of cyber synchronous strategies allowed a teacher based at BSDE and students located within Australia and around the world to interact with each other in a virtual environment using a synchronous cyber classroom. Textual information was shared on an interactive synchronous whiteboard. Participants used Voice over Internet Protocol (VoIP) to listen and speak with each other, along with a chat-room for messaging. Webcams were used to allow participants to see each other *via* a live video stream. Findings from the trial at BSDE indicated that the cyber synchronous classroom could be used to great effect to overcome the isolation experienced by many students in distance education settings (Hastie, Chen & Kuo., 2007; Hastie, Chen & Todd, 2008; Hastie et al., 2010). Despite the lack of technological infrastructure, and the initial ambivalence within my workplace towards the use of the cyber synchronous classroom, further trials of TEL were undertaken, commencing 2004, through collaboration with the National Sun Yat-Sen University (NSYSU), Taiwan. The partnership saw the provision of IT hardware in the form of the Collaborative Cyber Community (3C) platform. This international collaborative partnership yielded a decade of research findings that was published in peer-reviewed educational journals and shared in Australasian and global forums. Since then, the uptake of cyber synchronous teaching and learning has become common practice in distance education settings in Queensland and throughout Australia, with positive gains in student learning reported (Hastie, Chen & Smith, 2011; Stacey, 2005).

This study, then, builds on the research undertaken during the past fifteen years at BSDE. While the study was situated in Queensland and it is predicted that direct parallels will be drawn between BSDE and other schools of distance education in Queensland, the findings are expected to have wider implications for Australian education in terms of the skilling of students for digital futures. The anticipated implications for Australia of the use of digital technologies will now be discussed.

### **1.3 Implications for Australia**

The digital age continues to transform education locally and globally; however, when compared internationally Australian students are continuing to fall behind, particularly in Science, Technology, Engineering and Mathematics (STEM) learning (Australian Government, 2014c; Office of the Chief Scientist, 2014). In analysing the performance of Australian students in the PISA 2012 tests, Thomson, De Bortoli, & Buckley (2013) report the following results:

- Australia's mean mathematical literacy performance declined significantly between PISA 2003 and PISA 2012 (by 20 score points on average).
- Australia's mean score in scientific literacy has not changed significantly between PISA 2006 and PISA 2012.
- Australia's mean reading literacy performance declined significantly from PISA 2000 to PISA 2012 (by 16 score points on average). There was a significant decline in the performance of students at the 75th and 90th percentiles.

Clearly, Australian students need to develop greater STEM learning capability. One technology, educational robotics, is being heralded as the 'all-in-one technological learning tool' for STEM teaching (Eguchi, 2014b, p.34). Educational robotics, it is claimed, comprise a transformational tool for learning computational thinking, coding, and engineering, that is critical to STEM learning in K-12 education (Eguchi, 2014b). The benefits therefore in skilling students in robotics to prepare them for 21st Century futures would appear to be obvious, along with the growing market for educational robots, (Wintergarden Research, Inc.,

2014; OECD, 2013), and increased global emphasis on STEM learning; however, schools in Australia struggle to provide robotics instruction. For students in many parts of Australia, access to robotics education presents seemingly insurmountable challenges. The lack of access to robotics for many Australian students is due in large part to the prohibitive costs associated with sending a physical robotic device to each student, or with having students travel to centres where they can interact with robots. Clearly, there are serious and on-going impediments to the teaching of robotics and STEM in Australia.

In the new *Australian Curriculum: Technologies - Digital Technologies*, Australian Curriculum, Assessment and Reporting Authority (ACARA, 2015b), there is provision to redress this situation. Content descriptions are stated for 'Digital Technologies Processes and Production Skills' for each year level from Foundation to Year 10 (F-10). Year 5 and 6 students, for instance, are expected to learn to design, modify and follow simple algorithms involving sequences of steps, branching, and iteration or repetition (ACTDIP019). The elaborations indicate this can be done through designing the instructions for a robot. Students in Year 5 and 6 are also expected to implement digital solutions as simple visual programs involving branching, iteration or repetition, and user input (ACTDIP020). Once again, the elaborations show this can be learned through programming a robot to operate independently, for example, to find its way out of a maze. With the indication that Australian students can learn using robots, (ACARA, 2015a), it is imperative that we find solutions to enable more Australian students to learn using robots to boost STEM learning, particularly those students who cannot access physical robots. One solution proposed here is the use of an emerging digital technology, a Long Distance Control Robot (LDCR) system (Minamide, Takemata, Naoe, Yamada, & Hoon, 2008; Minamide, Takemata, & Hoon, 2009). The use of the LDCR system can enable students to learn to operate a Lego NXT robot remotely over the Internet, irrespective of their physical location, as shown in Figure 1.

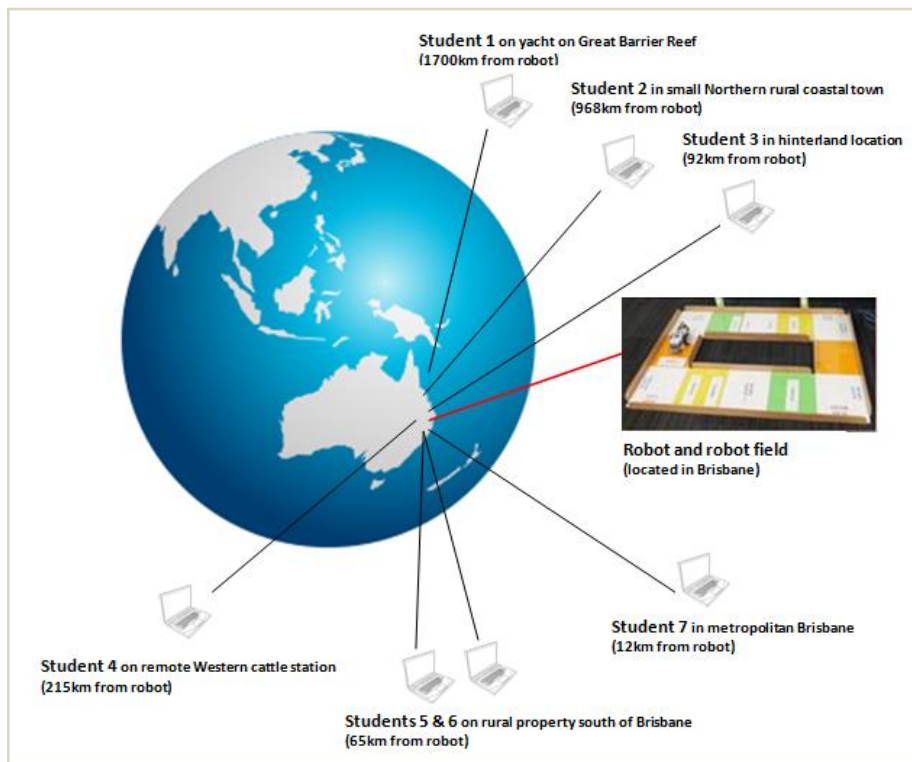


Figure 1: Robot operation by students in physically remote locations via LDCR system

For students living in rural, remote and isolated locations throughout Australia, access to the LDCR system means distance will no longer be a barrier to robotics education. To determine whether this remote use of robots addresses Australia's need for enhanced STEM education, research was needed to quantify the educational values for Australian students of engagement with robots from a distance using a LDCR system. The aim of the research was to establish whether the use of a LDCR and educational robots could be used to skill Australian students in digital technologies. An analysis of student perception of their learning when they operate a robot was required to determine the effectiveness of their learning of STEM skills. It was anticipated that important new findings would be derived from such a study that would contribute to current pedagogical and technological understandings of the teaching of digital technologies. In turn, these findings may offer solutions to educators elsewhere who face similar challenges in integrating robotics technology into education, challenges that are amplified in Australia by geography and distance.

Finally, I believed such a study would be groundbreaking because scant evidence exists in Australia, or internationally, of studies in which a LDCR system has previously been used by primary students to operate a robot remotely. This study therefore forms part of the continuing story of distance education in Australia and the application of innovative technological solutions to overcome the 'tyranny of distance'. Rather than being a tyrant or barrier, this work takes the position that distance provides unlimited opportunity because it opens new frontiers for technological innovation that can be of benefit to all Australian students and to our nation, a theme that has continued to underpin my educational pedagogy and practice (Hastie et al., 2007, 2010, 2011; Hastie, Minamide, Takemata, Chen & Smith, 2013).

## **Summary**

This study sought to find solutions through the use of digital technologies to ensure all Australian students, irrespective of their physical location, have access to the skills they need to adapt to a changing labour market and stay competitive in the global economy. As the boundaries between humans and machines become more and more blurred, our relationships with robots have become increasingly complex and will continue to do so. We can only imagine the future in which today's students will operate; a future where robots will continue their migration into traditional white-collar jobs and all areas of human activity.

The aim of this study then, was to determine the extent to which the use of a LDCR system impacts on the ability of students to use digital technologies, and if it is possible to engage greater numbers of students, both locally and globally, in studies of robotics through the use of a LDCR system. To cut to the chase, we need to ensure Australian students can compete in an increasingly technology-driven global economy and in a world where robots are becoming all pervasive. It is my hope this study will garner and leverage wider support in Australia for the use of emerging digital technologies such as the LDCR system, so our students are placed in the top ranks of innovation in ICT globally.



## Chapter 2

### Literature Review

#### 2.1 Introduction

This chapter reviews the literature to investigate the skilling of Australian students in digital technologies through the use of educational robots. While it is imperative that Australian students become highly skilled in a wide range of digital technologies (Australian Government, 2014c), the specific focus here is educational robotics. As the literature review will reveal, most research on educational robotics is based on the physical manipulation by students of the robots with which they interact. That is, the students are in the same physical space as the robots. A fundamental point of difference in this study is that the students were primary students aged 9-12 years and were physically distanced from the robot that was located in Brisbane. The students in this study operated the robot remotely using the Long Distance Control Robot (LDCR) system over the Internet. As such the use of the LDCR system for remote operation of robots by primary school students represents an innovative application of technologies that have been enabled by the advent of the Internet.

The study coincides with the endorsement in 2015 of the new *Digital Technologies* curriculum (ACARA, 2015b) in which Australian teachers are encouraged to teach STEM through the use of robots. However, for students in many parts of Australia, access to robotics education presents seemingly insurmountable challenges.

Global developments in the teaching of Information Communication Technologies (ICTs) are examined to determine their implications for Australian education, with a focus on innovative technology enhanced learning (TEL) solutions, specifically the use of robots from a distance. Current research findings on the use of a Long Distance Controlled Robot (LDCR) system are synthesised to determine potential applications in the preparation of Australian students, irrespective of their geographic location, for futures where robots will be all pervasive. An historical overview of the development of distance education in Australia provides a context for this study.

#### 2.2 Geography, distance and education in Australia

From the first centuries of the modern age, the ancient Greeks and Romans theorised about a vast southern landmass, '*Terra Australis Incognita*' that lay beyond the Indian Ocean. It would take another thousand years and a journey of over nine thousand nautical miles before Captain Edward Cook of the British Royal Navy located, charted and named Australia (State Library of New South Wales, 2014) using what might today be regarded as rudimentary navigational equipment. Prior to Cook's landing in 1770, humans had occupied Australia for over 55,000 years. Comprising over 500 different clan groups or 'nations', these first Australians had distinctive cultures, beliefs and languages (Australian Government, 2014a). They were nomads who invented a range of technologies, predominantly weapons and tools for hunting, devised from materials found within their natural environment, albeit a barren island continent that would soon be immortalised in poetry as 'the wide brown land' (MacKellar, 1909).

Thus, the young nation, known today as 'Australia', has long been associated with vast expanse and 'distance'. In fact the term 'the tyranny of distance', ascribed to Australian

historian Geoffrey Blainey (1966), came to define Australia's geographical distance from many parts of the world and encapsulated the often extreme isolation experienced by non-metropolitan, rural and remote sectors of Australia's small and widely distributed population. As a consequence, 'distance' demanded bush 'logic', improvised solutions and the development of innovative uses of technology, all of which shaped Australia's early history (Australian Government, 2014a). Such improvisation and innovation is acknowledged as a distinctively Australian strength.

The Federation of Australia in 1901 saw the British Parliament pass legislation that allowed the hitherto separate colonies to become part of the Commonwealth of Australia (Australian Government, 2014a), but continue to govern in their own right. This included the provision of education which remained the responsibility of each colony, renamed 'states' in the constitution. Although Federation had brought unity to a young nation, it could not compensate for geography and the tyranny of vast 'distance'. Nowhere was the tyranny associated with distance more evident than in the challenges faced by families working and living in the Australian 'outback', in gaining even the most basic education for their children (Blainey, 1966).

Throughout Australia, the need to provide educational services to isolated students continued to present challenges. In Queensland, the challenge of educating isolated students was addressed through the appointment by the Department of Education of the first visiting itinerant teacher in 1901. Itinerant teachers frequently travelled on horseback to reach the homes of students living in remote locations. The itinerant teacher program continued until the 1980s and was augmented, in 1922, by the Queensland Primary Correspondence Schools. Lessons were delivered by mail and these correspondence and print based learning materials formed the foundation of the Queensland distance education delivery mode (Queensland Government, 2014).

### **2.3 Schools of the Air**

From the late 1940s, isolated children gained access to lessons *via* the School of the Air (SOTA), using the Royal Flying Doctor Service (RFDS) High Frequency (HF) radio service (Ashton, 1971). The first SOTA broadcast was made in 1948 from the Alice Springs RFDS base (Alice Springs SOTA, 2014). By the turn of the century there were some sixteen Schools of the Air located around Australia, with the exception of the Australian Capital Territory and Tasmania, in a network that covered more than 1.5 million square kilometres. In Queensland the first School of the Air was opened at Cloncurry in 1960, followed by centres in Mount Isa, Charleville, Longreach, Cairns and Charters Towers. Described by the former Prime Minister of Australia, Sir Robert Menzies, as having made 'the single greatest contribution to the effective settlement of the far distant country that we have witnessed in our time' (RFDS, 2014), it is apparent the RFDS radio not only saved lives but enabled isolated students to gain an education, albeit pedal-powered and often *via* an intermittent radio signal. Moreover, the use of the RFDS radio service by the Schools of the Air exemplified the innovative and pioneering spirit of the 'bush' in overcoming the 'tyranny of distance' for isolated students and their families.

Then, as newer technologies emerged in the mid to late 1900s, including the motor car which replaced the horses of the itinerant teacher days (Wallace, 1989), followed by improved telephone services and eventually satellite, the educational options for these students expanded (Stacey, 1998). The term 'distance education' started to be used to describe learning

accessed from off-campus (Robertson, 1987), for students who were geographically isolated, travelling and itinerant, home-based, and those with medical conditions or disabilities.

## 2.4 Schools of Distance Education

In the late 1980s in Queensland, the name ‘School of Distance Education’ replaced ‘School of the Air’, followed by the establishment of the ‘School of Distance Education Brisbane Centre’ in 1989 through an amalgamation of the Correspondence Pre-School, Primary Correspondence and Secondary Correspondence Schools (Queensland Government, 2014). Then in 1992 this Centre was renamed the Brisbane School of Distance Education (BSDE). In servicing the learning needs of K-12 Queensland students, along with a considerable population of Queensland families and students living overseas, BSDE provided a program that consisted mainly of print materials, supplemented with audio-visual resources. The delivery mode was predominantly asynchronous with minimal contact between students and teachers (Brisbane School of Distance Education, 2014).

Then in 2005, delivery of lessons using the telephone commenced. While telephone lessons greatly enhanced communication for distance education teachers and students, it came at a cost to the Queensland Government of over one million dollars (Stacey, 2005). The advent of the Internet in the mid-1990s heralded the beginning of the digital age. It provided a global system of interconnected computer networks that would challenge the very notion of ‘distance’. As Leiner et al. (2012, p.1) state:

*The Internet is at once a world-wide broadcasting capability, a mechanism for information dissemination, and a medium for collaboration and interaction between individuals and their computers without regard for geographic location.*

During this period, teachers at BSDE were applying technology enhanced learning (TEL) solutions to enable real time, synchronous, teaching and learning over the Internet (Hastie & Palmer, 2003; Hastie & Chen, 2006; Hastie et al., 2008) that involved collaborative research with partners in the Australasian-Pacific region. These TEL solutions included strategies for managing cognitive load in e-learning settings (Hastie et al., 2012), investigations of instructional design for best practice in the synchronous cyber classroom (Hastie et al., 2007), the use of TEL to build bridges across the ‘Digital Divide’ towards ‘empowerment’ in Australia and the Asia-Pacific Region (Hastie et al., 2009), the development of a blended synchronous learning model for educational international collaborations (Hastie et al., 2010), the negotiation of content with learners using technology enhanced teaching and learning solutions (Hastie et al., 2011), and the definition of the role of the e-learning manager in re-engineering educational paradigms (Hastie et al., 2010). Building on Australia’s proud tradition as a provider of distance education, this work sought to contribute to the continuing story of the application of innovative technological solutions in the overcoming of the ‘tyranny of distance’, a theme that continues to underpin educational policy and practice in Australia (Stacey, 2005). From print materials delivered on horseback by itinerant teachers and broadcasts to isolated students over the RFDS radio service, contemporary Australian distance education has been completely transformed by digital technologies.

Contemporary classrooms in Australian schools of distance education now feature blended learning settings that combine asynchronous and synchronous modes of delivery and the sharing of digital resources by e-learning managers and students (Hastie et al., 2010). However, while the twenty-first century has seen a period of unprecedented change

worldwide, due in large part to the exponential growth of telecommunications networks, serious concerns have been raised about the skilling of a changing labour market requirement and the ability to compete in the global economy (Office of the Chief Scientist, 2014). At the centre of the demand for a skilled workforce is the need for familiarity with Information Communication Technologies (ICTs) and their usage, which is regarded as a prerequisite for accessing basic public services and exercising the rights and duties of citizenship (OECD, 2013).

## **2.5 Education for 21st Century Australia**

In Australia, the focus of government has been on the development of a skilled 21<sup>st</sup> Century workforce through education. The Melbourne Declaration on Educational Goals for Young Australians, announced in 2008, was an articulation of a set of nationally consistent future directions and aspirations for Australian schooling. Supported by the Council of Australian Governments (COAG) National Education Agreement (NEA), the Declaration is a commitment to the acquisition by all Australian school students of the knowledge and skills required to participate effectively in society and employment in a globalised economy. Specifically, these new directions and aspirations included the promotion of equity and excellence with the expectation that all young Australians would become successful learners, who are confident and creative individuals, and active and informed citizens (ACARA, 2015a).

In line with global trends that identify the need to develop ‘key information-processing skills’ for all students, the Australian government prioritised the teaching of literacy, numeracy and problem solving within the context of technology-rich environments (OECD, 2013). Regrettably, the performance of Australian students continues to rank below the average in standardised international tests such as the Program for International Student Assessment (PISA), a survey that measures the knowledge and skills of 15-year-olds, who are near the end of schooling in most of the participating education systems (PISA 2012). The survey conducted by PISA in 2012 assessed the capacities of students in over 70 economies around the world to apply knowledge and skills in mathematical, scientific and reading literacy. Approximately 14,500 Australian students from 775 schools were measured in the assessment that was conducted by the Australian Council for Educational Research (ACER) for the OECD. When Australian students were compared with other OECD countries, the literacy scores for mathematical, scientific and reading were wider than the OECD average, indicating that a larger gap exists between the lowest and highest achieving students (Thomson et al., 2013). These results have been the subject of considerable public scrutiny and debate with the former Federal Minister for Education and current Minister for Industry, Innovation and Science, The Honourable Christopher Pyne MP, saying they were “a serious wake-up call for the Australian education system” (ABC News, 2013).

The curriculum areas of ICT and design and technology are seen as central to lifting the performance of Australian students for post-school success and to the development of a skilled Australian economy that can compete in the global marketplace. Through the implementation of the new *Digital Technologies* curriculum (ACARA, 2015b), the goal is to produce enterprising individuals who can make discerning decisions about the development and use of technologies. The curriculum states:

*All young Australians should develop capacity for action and a critical appreciation of the processes through which technologies are developed and how technologies can contribute to*

*societies. They need opportunities to shape and challenge attitudes to the use and impact of technologies. They will do this by evaluating how their own solutions and those of others affect users, equity, sustainability, ethics, and personal and social values. In creating solutions, as well as responding to the designed world, they will contribute to sustainable patterns of living for themselves and others* (ACARA, 2015b).

Furthermore, the Australian Government, in its white paper, *Australia in the Asian Century* (2012), emphasises the need for Australia as a nation to do more to develop capabilities that will meet the emerging challenges of this century. Ongoing reform and investment in skills, education and innovation are correlated with Australia's productivity performance to ensure all Australians can participate and contribute. Capabilities that include job-specific skills, scientific and technical excellence, adaptability and resilience are identified as particularly important for the Asian century.

The development of these capabilities in Australia echoes trends world-wide that have seen the subject areas of Science, Technology, Engineering and Mathematics, known as 'STEM', take 'centre stage' for policymakers, curriculum designers, as well as researchers (Australian Government, 2011). While STEM education is now recognised as pivotal to increasing our nation's productivity, recent commentary on Australia's performance around STEM suggests that Australia is at a competitive risk both globally and in our region (Marginson, Tytler, Freeman & Roberts, 2013). Co-author of this report for the Australian Council of Learned Academies, Professor Russell Tytler, stated:

*In world terms Australia is positioned not far below the top group but lacks the national urgency found in the United States, East Asia and much of Western Europe, and runs the risk of being left behind.* (p.12)

Indeed, the teaching of STEM in Australia attracted strong criticism from Australia's former Chief Scientist Professor Ian Chubb (Office of the Chief Scientist, 2014). Chubb's report: *STEM: Our Future* (Australian Government, 2014c), is a damning indictment of the current situation in relation to STEM in Australia. He states:

*We are locked in a cycle of disengagement that fails our teachers and students today - and puts business at risk into the future. The Australian Industry Group and the Business Council of Australia are now calling for action to prepare more work-ready STEM graduates, from all social backgrounds, to deepen our talent pool and lift national economic growth* (Australian Government, 2014c, p. 23)

Chubb points out that Australia is now the only country in the OECD not to have a current national strategy that bears on science and/or technology and/or innovation. He identifies the lack of a national strategy as a major impediment to building a stronger Australia with a competitive economy. In redressing the situation, the report recommends that Australian education should focus on the preparation of a skilled and dynamic STEM workforce. Such a workforce, it is envisioned, will lay the foundations for lifelong STEM literacy in the Australian community, beginning in childhood and constantly renewed as knowledge and technologies expand (Australian Government, 2014c).

Key recommendations include support of the national interest by maintaining a secure 'pipeline' of STEM graduates, and increased recognition of STEM education and careers as a public good, inspirational teaching whereby all pre-service and in-service STEM teachers are

provided with training and professional development opportunities to deliver contemporary science using contemporary pedagogy, with a focus on creativity and inquiry-based learning, in alignment with the way science is practised, inspired learning using curricula and assessment criteria, from primary to tertiary levels, to promote the development of long-lasting skills, including quantitative skills, critical thinking, creativity, and behavioural and social skills, in parallel with disciplinary knowledge, while at the same time ensuring that changes to the Australian Curriculum do not diminish the place of STEM, a skilled workforce in which the skills of STEM graduates are aligned with workforce needs; and the facilitation of a community that is engaged with STEM.

To reiterate, Australian students are now expected to learn using robots (ACARA, 2015a), learning that has been identified as critical and fundamental to the development of a twenty-first century skilled and dynamic STEM workforce. The literature is now reviewed to determine how Australian students could be prepared to achieve these skills and employment outcomes.

## **2.6 Educational robots**

The robotics revolution that so radically reshaped industry, defence, energy (nuclear), health and entertainment (Amad et al., 2014), during the last century, is now transforming 21<sup>st</sup> Century education. Mataric (2004) predicted over a decade ago that robotics would have a significant impact on the nature of engineering and science education from Kindergarten to graduate level. Barak & Zadok (2009) found the benefits of robotics are related to concepts in science, technology and problem-solving skills. They concluded that educational robotics have enormous potential as a learning tool, including supporting the teaching of subjects that are not closely related to the robotics field.

Today, educational robotics is frequently referred to as the ‘mother’ of all subjects, because it integrates mechanical, electrical, control engineering, computer science, technology, electronics, math and science (STEM Center USA, 2014). Increasingly robotics is acknowledged as an ‘all-in-one technological learning tool’, as a transformational tool for learning computational thinking, coding, and engineering, and critical to STEM learning in K-12 education (Eguchi, 2014b). In addition, the intrinsically digital nature of robots means their use as instructional tools leverages the sharable and preservable characteristics of digital data, an imperative in increasingly digitalised and global economies (Chang, Lee, Chao, Wang, & Chen, 2010).

Historically, the timeline for the development of educational robots is comparatively brief. Starting in the 1960s, the appearance of the first educational robots coincided with the introduction of the programming language LOGO and a floor turtle, a robot that could follow directions by connecting to a computer. Invented for young children by Seymour Papert of Massachusetts Institute of Technology (MIT), the use of a basic computer language meant the children could program a turtle robot to move, using simple instructions and pen mechanisms that allowed them to program and create a design on a sheet of paper (Resnick, 1994). The computer programming language involved children in learning how to ‘teach’ the turtle to draw basic shapes, such as triangles, squares, circles, and letters, plus more complex Spirograph-like shapes through the repetition of simpler shapes and slight rotations of the turtle before each repetition. It was anticipated that these simple commands, albeit two-dimensional, could be used to engage students in thinking about complex mathematical ideas, such as Geometry, because the turtle was viewed metaphorically as an object with which to

think.

Papert's approach, sometimes called body-centred geometry, was based on findings that children learn abstract geometric concepts more easily if they can model geometric forms in physical space, and they learn even more quickly when they were asked to rehearse geometric forms using their own body (Papert, 1980). Papert's work, then, was seminal as it helped bridge the gap between abstract computation and the learning abilities of children by bringing computer programming into the physical world as a creative activity (McNerney, 2004).

However, while qualitative data on student enjoyment of working with LOGO had provided teachers with subjective evidence of its power as a teaching tool, there existed relatively few quantitative evaluations of LOGO or the claims made by classroom proponents. Part of the problem, according to McKerrow (1982) involved developing a rigorous control group methodology for assessing the impact of computers and robots on the educational process. Then, the proliferation of personal computers in the late 1970s saw the focus of the LOGO community shift to digitised 'screen turtles', the simulated version of the floor turtle that was found to be faster and more accurate than its mechanical forebear.

## **2.7 The first LEGO-based educational products**

LEGO construction blocks were extended in 1986 by the marketing of a new variation – Lego Technic (LEGO, 2012). The variation included motors, lights and sensors that linked to an electronic control box programmed using LOGO. In effect, the innovation meant that LEGO and MIT Media Lab (USA) had brought the 'turtle' off the screen and back into the real world (Resnick, 1994). Using a basic kit of parts, students were able to create, test, modify, disassemble and recreate multiple and different robotic machines and mechanisms, without any damage to the building materials (LEGO, 2012). The new setup was marketed as 'LEGO TC Logo' and became a popular educational tool, the precursor to the Lego robotics resources, that has enabled students to build their own machines prior to programming them (Resnick, Ocko, & Papert, 1988), rather than being given ready-made mechanical objects (Resnick & Ocko, 1991).

It also marked a shift of focus in the late 1990s for academics at MIT, including Australian Rodney Brooks, to small, smart useful robots. LEGO heralded this change of focus with the release in 1998 of their first Robotics Invention System, named 'MINDSTORMS' in recognition of Papert's seminal work of 1980 (LEGO, 2012). Since then, the interest in educational robots, beginning in the 1960s with the prototypical mechanical floor turtle, has grown exponentially. The global market sales for educational robotic kits, for instance, are predicted to reach 35.8 million units in 2014, growth that is attributed to the popularity of robots worldwide and their capacity to transcend national boundaries (Wintergreen Research, Inc., 2008).

## **2.8 International emphasis on computer coding**

Renewed emphasis internationally on computer coding and engineering design has become a major focus in school curricula. In the United Kingdom (UK), for instance, the new 2013 curriculum framework emphasised computer coding and engineering design. Currently, the aim in the UK is for every primary school student to have the opportunity to explore the creative side of computing through writing programs, and for all secondary school students to

have the opportunity to work with microcontrollers and simple robotics (Department for Education, the U.K., 2013).

Similarly, curriculum initiatives in the United States of America (USA) have placed the development of 21st Century Skills at the core of its educational reform (Eguchi, 2014a), with the ingenuity, agility and skills of the American people, through 21st century readiness for every student, seen as crucial to the competitiveness of the USA (The Partnership for 21st Century Skills, 2008). Furthermore, American students have been urged by their government to immerse themselves in robotics that is described by STEM Center USA (2014) as the most forward-looking discipline of our time. Among the recommendations made by the STEM Center USA (2014) was the call for wider participation by American students in robotics competitions as a popular way to engage students through hands-on learning to raise their interest in STEM (Robinson & Stewardson, 2010).

Quantifiable gains are claimed for students who use educational robots, from early childhood to tertiary level and in a range of technology enhanced learning settings. For instance, Wang, Young & Jang (2013) found higher levels of concentration and engagement in spoken English when advanced speech recognition techniques were combined with educational robots in the form of tangible companions to enhance the English conversation skills of primary students ( $n = 32$ ). In a similar study, Fridan (2014) used an interactive robot as a teacher assistant to tell pre-recorded stories, incorporating song and motor activities, to small groups ( $n=10$ ) of children aged 3 to 3.6 years of age. The children, it was reported, enjoyed interacting with the robot and accepted it as an authority figure. In an analysis of participant interactions with a physical robot and its virtual embodiment, Hoffman & Krämer (2013) found children perceived the robot as more competent than the virtual character in the task-oriented scenarios, but the opposite was found to be true in persuasive-conversational scenarios.

## **2.9 Australian robotics programs**

In an ethnographic study conducted in Australia by Mills, Chandra & Park (2013), a series of collaborative robotics programming tasks were used to examine the role and architecture of language in children's learning and problem solving (Vygotsky, 1962). Robotics design challenges were created among students ( $n=24$ ) aged 8.5 to 9.5 years using Lego Mindstorms<sup>TM</sup> toolsets. Key patterns and principles of public language were identified within these challenges. Findings indicated the use of language by the students in the study was central to both their creation of new relationships in the learning environment and to the mental organisation that was required for problem solving using robots. Thus, understanding the role and architecture of language in collaborative learning, along with the child's capacity for its application, was determined to be fundamental to social cognition and cultural learning. The study concluded Vygotskian principles could be extended to other pedagogical situations, specifically collaborative problem solving in the STEM disciplines.

The use of digital technologies, specifically robotics, in the early years of formal schooling was the subject of an Australian pilot study undertaken by McDonald & Howell (2012). The study investigated the development of literacy, numeracy and STEM using the LEGO Robotics *WeDo* program (LEGO Group, 2015), with students aged 5.6 to 7 years ( $n=16$ ). The students were from diverse cultural and ethnic backgrounds. Findings from the study indicated that the use of digital technologies such as robotics could contribute to enhanced student engagement and interpersonal skills. This study, then, demonstrated that the provision



of digital access and robotics education for disadvantaged learners in the early years could contribute to their emergent literacy, numeracy and STEM concept development.

Various research studies have quantified the impact on learning when students interact with physical robots compared to simulated robots. For instance, in a study undertaken by Bacivarov & Ilian (2012), hands-on laboratory time was found to be a more productive learning experience for tertiary students resulting in a greater level of knowledge assimilation when compared to a simulation-exclusive approach. While this study highlighted the current focus by most university level robotic technical education on simulation, it demonstrated that students prefer practical and physical experiences, not simulations. Furthermore, comparative class evaluations of tertiary students who had used an advanced, low-cost robot in STEM education, rather than simulations, recorded consistently above average scores, indicating greater interest in and understanding of engineering and other advanced STEM subjects (McLurkin et al., 2013).

In promoting STEM through coding, computational thinking and engineering skill learning, a range of robotics projects have been identified by Eguchi (2014a, 2014b). These include the 'WaterBotics' curriculum (<http://waterbotics.org/>) in which small groups of students in the United States were involved in the collaborate design, construction, testing, and redesign of underwater robots; the 'RoboParty' (<http://www.roboparty.org/en/>) robotic camp conducted in Portugal through which students were encouraged to learn electronics, mechanical design and programming in preparation for team competitions where they showcased their robotic creations and algorithms; and the 'RoboCupJunior' (RCJ) educational robotics initiative through which students, up to the age of 19 years, participated in soccer, rescue and dance challenges or leagues. For older participants, 'RoboCup', the Robot Soccer World Cup Championship is conducted annually in a different location around the world, attracting over 250 teams internationally. With the goal to have a fully automated team of robots beat the world's best soccer team by the year 2050, the future for 'RoboCup' would seem to be assured. The global interest in events such as 'Robocup' and 'RoboCupJunior' is indicative of the growing acceptance of educational robots in schools and the community, and their elevated status in education due to their association with high level learning outcomes (Eguchi, 2014a, 2014b).

Results from a study of student learning following their participation in 'Robofest' ([www.robofest.net](http://www.robofest.net)) competitions indicated improved and higher scores in the STEM subjects of Mathematics and Science (Chung, Cartwright, & Cole, 2014). The benefits of participation by students in robotics projects such as those cited by Eguchi (2014a, 2014b), and Chung et al. (2014), support the earlier findings of Robinson & Stewardson (2010), in which hands-on learning using robots was correlated with an increased interest in STEM. In particular, students applied engineering skills when constructing robots for specific challenges, and used mathematical problem solving and coding to program and evaluate the direction, movement and speed of the robots. It can be concluded from these studies that, given the opportunity to interact with simulated and physical robots, students across the learning spectrum from early childhood to tertiary level, prefer to interact with physical robots, and that this type of experience accelerates cognition and STEM learning and enhances student engagement and interpersonal skills.

## **2.10 Learning through remote controlled devices**

The literature clearly points to the need for Australian students to access robotics education to

enable them to compete in the 21<sup>st</sup> century global economy (Office of the Chief Scientist, 2014; Australian Government, 2014c; ACARA, 2015a). Educators are urged, as a matter of urgency, to identify and apply innovative technological solutions. Exemplars can be found in fields such as Science and Medicine. For instance, in the specialty area of Astronomy, the world's first system for interactive remote control of a ground-based telescope on another continent was established in the late 1980s at the European Southern Observatory (ESO) in Chile. Using a computer-to-computer connection via a satellite link between the ESO installations in Europe and South America, astronomers were able to control a telescope from a distance of almost 12,000 kilometres. Observations, including direct images or 'spectra', were sent back in digital form *via* the same satellite link allowing the astronomers to undertake immediate analyses of the data and make decisions on how best to proceed with their research.

In later research, the PULSE@Parkes project in Australia has provided secondary school students with the opportunity to control the Parkes radio telescope in rural New South Wales *via* the Internet from the headquarters of the Australian Telescope National Facility (ATNF) in Sydney (Hobbs et al., 2009). Under the guidance of professional astronomers students observed pulsars, the post-supernova remnants of dead stars. Data was collected to determine various properties of pulsars with the results used by CSIRO Astronomy and Space Science (CASS) astronomers to test Einstein's theory of gravity (ATNF, 2014).

Similarly, the South Australia Telescope (SAT), currently under construction, will provide access to an automated research-grade 900mm (36-inch) reflecting telescope, and provide a technological and educational resource not available elsewhere in the southern hemisphere. The telescope and a charged-coupled device (CCD) camera will be operated remotely and synchronously *via* the Internet with images downloaded to a remote user in five minutes or less for asynchronous storage, processing and study (Astronomical Society of South Australia, 2014). This type of training and technology is opening the skies to students everywhere, including Australian students who now have the Universe at their fingertips.

In the field of Medicine, pioneering robotic surgery undertaken in the 1990s provided early technological solutions to enhance the capabilities of surgeons and improve patient care outcomes while reducing costs in the operating room. At the forefront of these innovations was an American surgeon, Dr Edward C. Rosser, Jr. Inspired by his work as the Assistant Professor of Surgery at the Yale University School of Medicine and technical coordinator for the Yale/NASA Commercial Space Center, Rosser used a combination of distance education and telemedicine to demonstrate the critical and fundamental role of the robot in enhancing the abilities of surgeons in the operating room. Through 'telementoring' and the direct control of the video image, this approach enabled a remote surgeon to collaborate and support the surgeon onsite. Then in 1997, the first node of the International Space Station was placed into orbit around Earth, creating new possibilities for remote controlled robotic surgery on astronauts (Yale University School of Medicine, 2014).

Recent developments in the use of remote sensing and tele-robotics have seen primary students in the USA (n=20) exploring and automating remote environments *via* the Internet (Portsmore et al., 2003). In collaboration with the Science, Engineering, NASA Site of Remote Sensing (SENSORS) project, students created a network of simulated environments, culminating in challenges that were solved using a physical miniature replica of the simulations. Despite technological difficulties associated with the motor output consistency of the Lego RCX robot and in maintaining student engagement due to the student-robot ratio

(20:1), positive outcomes were reported. The study concluded that the overall enthusiasm for the project had resulted in the establishment of a network of sites, and greater collaboration and outreach, that was more than any single institution, could manage at the time.

In another example of collaborative research, four universities in the UK worked on a trial of the Practical Experimentation by Accessible Remote Learning (PEARL) project. Experiments were conducted on spectroscopy, an introductory Science subject, in a distance learning setting (Scanlon, Colwell, Cooper, & Di Paolo, 2004). The aim was to provide remote access to laboratory work over the Internet for tertiary students. The laboratory access was directed at students with special needs who typically have difficulty due to mobility issues in accessing a physical laboratory. The spectrometer was adapted for remote operation with students undertaking experiments on light spectra, including a flame test procedure, observations of the special signature of a sodium lamp, and identification of unknown metal ions. Findings were encouraging with students reporting significantly improved experiences of laboratory work in remote settings when using the PEARL system. In a trial conducted by the University of Western Australia, a remotely controlled robot, the Internet Telerobot, allowed operators to pick up and move objects. The robot could be viewed live by a video camera and a chat facility enabled the operators to talk to each other. At the end of the six year study in 2000, the robot had been accessed by up to 500,000 users (Machotka, Nafalski & Nedić (2011). In a similar study undertaken in 2002 at the University of South Australia, engineering students were able to use NetLab hardware and software to conduct real experiments online that they controlled via the Internet (Machotka et. al., 2011). These studies confirm that the use of remotely controlled robots in educational settings is feasible but their impact awaits credible empirical evidence that student academic achievement is enhanced. Accordingly, the study reported here in a primary school setting builds on the usage of remote robot technology and analyses student outcomes to test the efficacy of the technology as a pedagogical tool.

Pioneering applications of remote controlled robotic devices such as those described above have captured our imaginations while their modern counterparts continue to astound us. In fact these remote controlled robotic devices prove that distance, far from being a barrier, is the new frontier for technological innovation. However, despite the obvious benefits in skilling students in digital technologies to prepare them for 21<sup>st</sup> Century digital futures, together with the growing global emphasis on STEM learning, schools in Australia struggle to provide robotics instruction. The perennial problems of geography and distance and the prohibitive costs associated with sending a physical robotic device to each student, or with having students travel to centres where they can interact with robots, are serious on-going impediments to the teaching of robotics in Australia. With the expectation that Australian students will learn using robots (ACARA, 2015a; Queensland Government, 2015), it begs the question: How do we teach digital technologies such as robotics to students, particularly those students who cannot access physical robots, and how do we measure the consequential learning?

## **2.11 The Long Distance Controlled Robot (LDCR) system**

An emerging digital technology, a Long Distance Controlled Robot (LDCR) system, has been proposed as a solution to the skilling of students in robotics at a distance, and has been the subject of a trial that commenced at BSDE in 2013 (Hastie et al., 2013). This LDCR system (comprising a Linux server that manages the control of a Lego NXT robot through a webpage) was accessed by students from their home computer. Students lived in a range of

rural and remote and metropolitan settings throughout Queensland. They used the LDCR system over the Internet to operate the robot that was located in Brisbane. Students controlled the robot synchronously through webcams using a set of commands (Forward, Back, Left, Right, and Stop) over the Internet *via* a Bluetooth signal (Minamide, Takemata, Yamada & Hastie, 2012). The signal connected the server and robot, as illustrated in Figure 2.

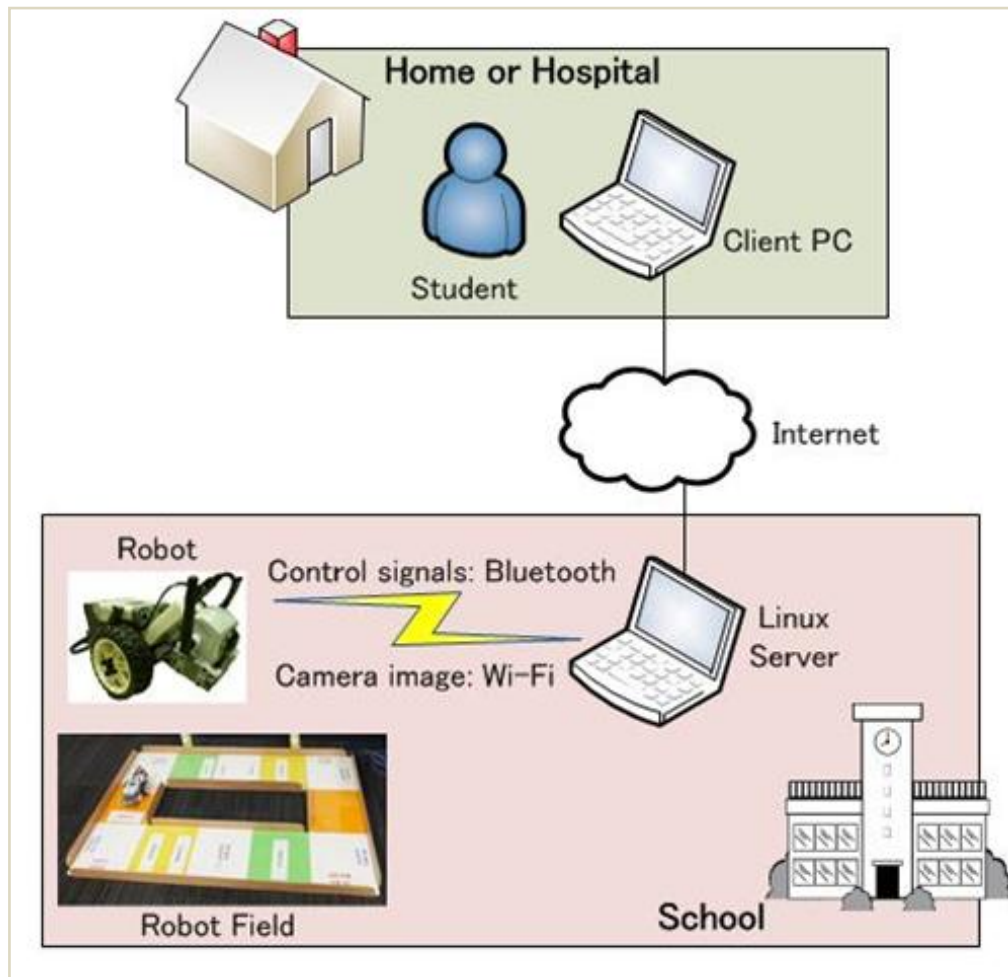


Figure 2: LDCR system used by students throughout the study

Earlier research conducted by Minamide et al. (2008) with students in Japan and Singapore, involved a trial of a 'Robocube' using a LDCR system. During the trial, various issues emerged including English translation and compatibility with the user interface (Minamide et al., 2009) and high costs associated with the 'Robocube' robot, that had been manufactured in Japan but was not easily accessed internationally (Minamide et al., 2012). A redesigned system sought to reduce costs and increase system security, while ensuring ease of operation of the robot by students and teachers. Consequently, the Lego Mindstorms NXT (Lego NXT) setup was selected due to its wider availability (Hung, Chao, Lee & Chen, 2013) and the new redesigned and purpose-built LDCR system was developed by Kanazawa Technical College (Minamide et al., 2012).

In the trial of the new LDCR system at BSDE, the Holistic Blended Learning Model was applied. The Holistic Blended Learning Model is based on fundamental elements of space and time, where space can be Physical or Cyber, and time can be Asynchronous or

Synchronous (Hastie et al., 2010). Therefore, the Model can be any combination of Physical Asynchronous (PA), Physical Synchronous (PS), Cyber Asynchronous (CA) and Cyber Synchronous (CS) elements, and these can be combined to create ten modes. Each mode can be represented as a formula, as shown in Table 1.

Table 1: The Holistic Blended learning Model

Mode	Holistic Blended Cyber Model Combinations
1	PA + PS
2	PA + CA
3	PA + CS
4	PS + CA
5	PS + CS
6	CA + CS
7	PA + PS + CA
8	PA + CA + CS
9	PS + CA + CS
10	PA + PS + CA + CS

In the Holistic Blended Learning Model the last mode, Mode 10, is considered to be optimal because it combines all components (Hastie et al., 2010). Using the optimal Mode 10, the students in this study accessed robotics-themed print and multi-media resources (PA), attended physical lectures on-site at BSDE (PS), accessed digital resources online (CA) and participated in cyber synchronous sessions in a virtual classroom (CS) throughout the trial of the LDCR system. While early indications from the trial of the new LDCR system at BSDE pointed to promising student learning outcomes (Hastie et al., 2013), scant evidence exists in the literature on the impact of the LDCR system on student learning. Three educational databases, Proquest, ERIC and A+ Education, were used to conduct searches of peer-reviewed articles that referred to robotics, education, distance and school learning from 1940-2014. The search results are recorded in Table 2.

Table 2: Educational database results

Query	Proquest	ERIC	A+ Education
Robotics	51528	398	120
Robotics + Education	9826	398	105
Robotics + Education + Distance	3397	13	4
Robotics + Education + Distance + School Learning	1715	3	2

The Proquest database identified the greatest number of articles, although significantly fewer articles were found on robotics learning in schools in which distance was a factor. The same result was recorded for the ERIC and A+ Education databases. Therefore, a *prima facie* case is made for new research on the impact on student learning of the LDCR system in distance education settings.

## 2.12 Research Questions

This study, then, proposed to investigate knowledge claims around the teaching of digital technologies using a LDCR system, based on the following research questions:

1. When students operate a robot, what are their perceptions of their learning?
2. What Science, Technology, Engineering and Mathematics (STEM) skills do students learn through robots?
3. What complementary skills do students learn when they operate a robot remotely using a Long Distance Control Robot (LDCR) system?

Complementary skills are defined here as those skills in which students described the procedures involved in using the LDCR system, the technical skills required to operate the robot using the LDCR system, and student explanations of their learning, specifically metacognition, when operating the robot remotely using the LDCR system. In answering these questions, it was anticipated new findings would be contributed to current pedagogical and technological understandings of the teaching of digital technologies such as robotics, and that these findings would address the challenges faced by educators everywhere in integrating robotics technology into education, challenges that are amplified in Australia by geography and distance.

## Summary

The literature is emphatic in recommending the preparation of Australian students for 21<sup>st</sup> Century futures through engagement with digital technologies. In particular, the research points clearly to a greater emphasis on STEM learning, with robotics education identified as a priority for Australian students. The increased emphasis on STEM is essential if young Australians are to be appropriately skilled to live and work in an increasingly competitive global marketplace, and in a world in which robots will be all pervasive. A major obstacle, however, to the realisation of the full potential of educational robotics, both in Australia and worldwide, has been identified in the methodology used to date in its research and development (Altin & Pedaste, 2013). Historically, the methodology that has informed the use of educational robots has been platform or hardware driven, resulting in a predominance of qualitative research over quantitative studies (Barreto & Benitti, 2012). What is needed is current research data that incorporates both quantitative and qualitative methodologies that is based on innovative applications of robotics technology as a compulsory part of the school curriculum (Office of the Chief Scientist, 2014; Australian Government, 2014c; ACARA, 2015a). In general the literature on educational research supports the use of a mixed methods approach to the collection and analysis of data through the combination of qualitative and quantitative methodology. The gathering of information from people's stories, in addition to the numbers (Creswell, 2013) is claimed to result in greater reliability, validity and rigor (Denzin, 2006), because decision-making is based on both quantities and qualities (Kaplan, 1964). However, Alimisis (2012) recommends a shift from qualitative to quantitative research methodology for research undertaken in the field of educational robotics. In this study, students were living in a range of rural and remote and metropolitan settings throughout Queensland. They used the LDCR system over the Internet to operate a robot that was located in Brisbane. The challenge in this study, then, was to ensure the research conducted on the use of the LDCR system was founded on robust data collection and rigorous analysis protocols, with greater emphasis placed on the quantification of data through the use of a mixed methods approach to analysis. The methodological approach used to achieve such rigor in this study is discussed in Chapter 3.

## **Chapter 3**

### **Methodology**

#### **3.1 Introduction**

In this chapter, the literature was reviewed in an attempt to situate the study within relevant methodological techniques and approaches. The term ‘methodology’ is defined here as the philosophical framework and the fundamental assumptions that have been applied to the research, and the word ‘methods’ is used to refer to specific techniques of data collection and analysis (Creswell & Plano Clark, 2007).

As revealed in the review of literature in the previous section, the preparation of Australian students for 21<sup>st</sup> Century futures through engagement with digital technologies, specifically robotics education, has been identified as a priority by the government along with a greater emphasis on STEM learning (Australian Government, 2014c). Conjointly, the need emerges for empirical evidence that identifies effective applications of robotics as an educational tool in schools. However, when Barreto & Benitti (2012) attempted to identify the existence of systematic reviews involving robotics in education, they concluded that no specific research on the subject could be found. Therefore, a more effective analysis of the potential of robotics as a teaching tool for schools could not be undertaken because few quantitative studies had been presented. Clearly, a gap exists in the literature in relation to empirical research methodology that can be applied to studies of educational robotics. This study, then, seeks to identify specific research methods and instruments that can be used to quantify the skilling of students in digital technologies using long-distance controlled robots over the Internet.

Overarching the approach to research methodology in this study was an ‘inductive’ model (Babbie, 2014). The research started with observed data from which patterns were identified. These patterns were used to explain the relationships between the observed objects, and to develop generalisations about educational robots. It was anticipated that such generalisations may then point to relatively universal principles about the use of robots in education. However, the approach in this study can also be described as ‘deductive’ because, according to Babbie (2014), it started with a hypothesis or general law about the skilling of students using robots, and applies it to a particular instance, which, in this case, was the use of a LDCR system. Thus, the never-ending alternation in theory and research between induction and deduction (Babbie, 2014), enabled the combination of qualitative and quantitative research protocols that have been applied to this study. As recommended by Creswell (2003), consideration was given in this study to the knowledge claims that are made, the strategies of inquiry that informed the procedures, and the methods of data collection and analysis that were used. This approach was intended to harness the advantages of both qualitative and quantitative research methods, and thereby holistically incorporate both inductive and deductive models.

In this study, case study design was applied to the methodology to investigate the skilling of students in digital technologies using long-distance controlled robots over the Internet. Case studies are defined here as the in-depth exploration of a program, an event, an activity, a process, or one or more individuals (Creswell, Hanson, Plano Clark & Morales, 2007). The case(s) are bounded by time and activity, and detailed information is gathered using a variety of data collection procedures over a sustained period of time, and within a ‘real-life’ context (Yin, 2003). Furthermore, the use of case studies enables the inductive identification of

additional variables and the generation of hypotheses (Eckstein, 1975). Thus, the application of case study methodology in this study was expected to be advantageous in dealing with the complexities associated with the LDCR system, as described here.

Throughout the study, data from multiple sources were collected and replicated (Yin, 2003) using three case studies. Then the data from each case study were analysed using a mixed methods approach to provide in-depth, contextual understandings specific to the use of educational robotics by primary students. Mixed methods is defined here as the process whereby the researcher collects and analyses data, integrates the findings, and draws inferences using both qualitative and quantitative approaches or methods in a single study or a program of inquiry (Tashakkori & Creswell, 2007), or in this case, through a series of case studies.

The three case studies were designed to investigate student perception of their learning when they operated a robot, their STEM learning through robots, and the development by students of complementary skills when they learned to operate a robot remotely using the LDCR system. Three research questions were developed from the case studies:

1. When students operate a robot, what are their perceptions of their learning?
2. What Science, Technology, Engineering and Mathematics (STEM) skills do students learn through robots?
3. What complementary skills do students learn when they operate a robot remotely using a Long Distance Control Robot (LDCR) system?

To provide a comprehensive answer to each of the research questions, a case study approach was applied to the analysis of the textual and numeric data collected. First, a literature review was undertaken to identify the philosophical assumptions on which to base the study, and to construct a theoretical framework. As revealed in the Literature Review in Chapter 2, the methodology that has historically informed the use of educational robots has been platform or hardware driven, resulting in a predominance of qualitative research over quantitative studies (Baretto & Benitti, 2012). Conclusively, the literature recommended a shift from qualitative to quantitative research methodology for research undertaken in the field of educational robotics (Alimisis, 2012). In response to the literature review findings, three pre-planned research questions were generated, based on the three case studies (Creswell et al., 2007; Yin, 2003; Eckstein, 1975), to investigate the skilling of students in digital technologies using a LDCR system. Then, the research design was determined according to which case study could be used to most appropriately answer the research questions using quantitative or qualitative data.

During the study, information, both quantitative and qualitative, was collected at strategic points, and at opportune times. Specifically, information was gathered when students were participating from off-site in online activities associated with the BSDE Robots Project 2014. The sample population for the study was drawn from a group of 32 students (n=32) who were aged 9-12 years and enrolled at BSDE during 2014. The students were selected because of their interest in robots, as demonstrated by their voluntary participation in the BSDE Robots Project 2014. As a consequence, data collection procedures were determined by student availability and aligned closely with the digital tools that were used by the students during the research study, specifically the LDCR system.

In answering the first research question, a quantitative data collection tool was used, in



accord with case study methodology, to analyse the numeric information that was collected. Self-administered surveys were distributed to participants to measure what they had learned before (Appendix A) and after (Appendix B) they had operated a robot using a LDCR system. While other quantitative data collection procedures, such as in-person surveys were considered, access to the students was restricted due to their geographic locations and the voluntary nature of their participation. Self-administered surveys were expected to provide information from which numeric data could be extracted and analysed, and a convenient and age-appropriate tool for the participants in the study.

For the second and third questions, qualitative data collection procedures were selected, consistent with case study methodology, to enable textual data to be captured, read and manipulated to create numeric data. Data were collected from multiple sources throughout the study and within the 'real-life' context of the BSDE Robots Project 2014. The aim of the data collection for the second and third questions was to determine the learning of STEM and complementary skills by students before and after they had operated a robot remotely using a LDCR system. The data included video recording transcripts (Appendix C) and a student blog (Appendix D). Students could access the blog at any time during the study and, as with the surveys, the blog was expected to provide a data collection mechanism that was more convenient for students than other qualitative measures. *Verbatim* video recording transcripts were created following remote operation of the robot by students from off-site using the LDCR system. The video recordings were made using the recording facility on Blackboard, which was the school's learning content management system.

Then the data were analysed according to themes that were identified in the surveys, the blog and the video recording transcripts to provide a set of numeric data. Finally, the three data sets were triangulated using the different data sources to provide different perspectives on the same phenomena. Each set of data was interrogated to determine how students perceived their learning about robots, their STEM skill learning through robots, and their learning of complementary skills through the remote operation of a robot.

To summarise, case study design (Creswell et al., 2007) was applied to the methodology to investigate the skilling of students in digital technologies using long-distance controlled robots over the Internet. Three case studies were used to gather detailed information using a variety of data collection procedures during 2014 within the 'real-life' context (Yin, 2004) of the BSDE Robots Project 2014. The application of case study methodology was expected to be advantageous in dealing with the complexities associated with the LDCR system, as described in this study (Eckstein, 1975).

In answering the three research questions posed in this study, a comparison of student learning (Kirkpatrick & Kirkpatrick, 2006), was undertaken before and after remote operation of a robot by students from a range of locations off-site, using a LDCR system over the Internet. Given that the majority of articles in the literature on the use of educational robots focus on tertiary and secondary students (Barreto & Benitti, 2012), this study is expected to contribute new findings to discussions on the skilling of students in digital technologies through its investigation of the use of long-distance remote controlled robots by primary aged students. The methodology for each research question will now be addressed in turn.

### **3.2 Research Question 1**

When students operate a robot, what are their perceptions of their learning?

In addressing the first question, the literature on student perception of learning was explored. Perceptions of learning effectiveness, or self-efficacy, were defined in the seminal work of Bandura (1986) as the belief we have in our capabilities to produce designated levels of performance. Furthermore, self-efficacy is influenced by prior experiences in the area of interest, observations of others completing the same or similar tasks, the feedback and encouragement received in relation to the execution of a task, and the emotional state of the participant (Bandura, 1986). Such perceptions or beliefs are formed in accordance with the information obtained from performance accomplishments (enactive mastery experiences), vicarious experiences, verbal (social) persuasion and psychological states and determine how we feel, think and motivate ourselves, and how we behave (Bandura, 1994, 1997). These can be correlated with the confidence of individuals in their ability to reach goals as a consequence of their actions (Hemmings & Kay, 2009). Subsequently, self-efficacy impacts on the degrees of effort an individual is prepared to invest in their learning, which in turn affects achievement (Moriarty, 2014). How then is self-efficacy measured?

The literature indicated that predominantly, quantitative strategies have been used to determine self-efficacy (Usher and Pajares, 2008). Specific measures of self-efficacy are recommended, as they are better predictors of subsequent performance, whereas global measures can conceal underlying differences between separate dimensions of the concept (Bandura, 1986). In a study based on Bandura's work, Moriarty (2014) examined the impact of research design on the predictive power of self-efficacy. An analytical framework was developed using specific measures of self-efficacy to determine the effects of an intervention aimed at increasing the mathematics competence of initial teacher education students. Tests of self-efficacy were conducted to measure the confidence of the students in their ability to solve mathematical problems and teach others to solve problems in the same areas. Competence tests of mathematics ability were then administered to the students at the start and end of the semester (n=81) and those who did not achieve minimum levels (80%) were offered additional support. The relatively small sample size was accommodated through the use of a repeated measures design. While the findings from this study support the use of specific measures of self-efficacy rather than global, the study identified issues that have implications for research design. In particular it was found that self-efficacy levels were higher when there was a close correspondence between items on self-efficacy scales and items on corresponding criterion-based tasks and minimal delay in the administration of the self-efficacy scales and related tasks.

In a similar study, Alkharusi, Aldhafri, Alnabhani, & Alkalbani (2014) used multilevel analysis techniques to explore the interplay between the assessment practices of teachers, student perception of assessment tasks, and the effect of student perception on academic self-efficacy beliefs (n=1,457). Quantitative research was undertaken using surveys where students and teachers were asked a series of questions on items relating to their self-efficacy beliefs and their perceptions of the assessment tasks rated on 5-point Likert scales. The demographic information assessed in the survey of students covered gender and age while the demographic information gathered for the teachers covered gender, teaching experience, and teaching subject.

Alkharusi et al. (2014) referred to a study by Dorman & Knightley (2006) where an examination was undertaken of the relationships between student perceptions of assessment tasks and their self-efficacy. In their study, Dornan et al. (2006) used a Likert-scaled

instrument to assess the motivation and learning strategies used by college students. Motivation was assessed to determine the value (intrinsic and extrinsic goal orientation, task value), expectancy (control beliefs about learning, self-efficacy) and affect (test anxiety) of students. Student learning strategies were categorised in terms of their cognitive, metacognitive, and resource management. Within these categories, scales of cognitive strategies including rehearsal, elaboration, organisation, and critical thinking, were established. Metacognitive strategies included the planning, monitoring, and regulating strategies used by students. Resource management strategies included the time management, study environment, effort management, peer learning, and help-seeking efforts of students. It was found that assessment tasks with a low degree of congruence with planned learning, authenticity, and transparency could have a detrimental effect on students' confidence in their ability to successfully perform academic tasks. Further to the categories identified by Dorman & Knightley (2006), the metacognitive strategies used by students will be discussed in terms of their relevance to the research design.

In the seminal work of Pintrich (2002), three categories of metacognitive strategies are identified. These include strategic knowledge, knowledge about cognitive tasks, and self-knowledge. Strategic knowledge is defined as student knowledge of general strategies for learning and thinking and includes rehearsal, elaboration, and organisational strategies (Weinstein & Mayer, 1986).

In this study, instances have been identified where students made connections between and among content elements as evidence of their organisational learning strategies, and hence their metacognition. Knowledge about cognitive tasks was matched with appropriate contextual and conditional knowledge, that is, the 'what' and 'how' as well as when and why students used these different strategies. Self-knowledge was equated with knowledge about the self (the person variable) in relation to both cognitive and motivational components of student performance. Metacognition then was associated with the development by students of knowledge of their strengths and weaknesses, their awareness of the breadth and depth of their knowledge base, and their awareness of the different types of strategies they would use in different situations. It was expected the analysis of the metacognitive strategies used by students in this study would provide a comprehensive insight into their learning strategies. The findings, then, from both Alkarusi et al. (2014), and Dorman & Knightley (2006), corroborate those of Moriarty (2014), particularly in terms of research design. These studies demonstrated that self-efficacy has a direct impact on learning and achievement, and these need to be considered in terms of the metacognitive strategies used by students (Pintrich, 2002).

While numerous studies on student self-efficacy have been conducted in traditional face-to-face classrooms, there are fewer on self-efficacy in online settings. Furthermore, limited research exists at the K-12 level whereas a more substantial body of literature exists on online learning in adult populations (Hawkins, Graham, Sudweeks, & Barbour, 2013). For the purpose of this study, the discussion now turns to student perception of learning in online environments, and the methodology around the measurement of the self-efficacy of digital learners.

In a study conducted by Zhan & Mei (2013), a comparison was made between tertiary students (n=257) in face-to-face and online versions of the same course at a university in China. Students were randomly assigned to the courses and their academic self-concept, social presence and attitudes towards the course were measured using an online survey

administered at the end of the course. While academic self-concept and social presence were acknowledged as important factors in determining student learning achievement and satisfaction, findings suggested they were not of equal importance. Online students, it was found, required a higher-level of social presence. These findings, while highlighting the need for rigorous research design, point to the need for the inclusion of metrics that determine the effect of social presence on perceptions of self-efficacy in online settings.

In another study, learner characteristics predictive of online course completion (n=135) of high school students were identified in an examination of the relationship between learner characteristics and performance (Roblyer & Marshall, 2003). Successful students scored higher in self-efficacy, individual initiative, organisational skills, and access to technology, and spent less time working outside of school. These results were replicated by Roblyer (2008) with a larger sample (n=4100) where an additional predictor of success, past performance, was also identified. The findings on self-efficacy were further corroborated in an examination of the relationship between student perception of teacher-student interaction and academic performance in a virtual high school that was undertaken by Hawkins et al. (2013). A survey was used to measure student perception of the quality and frequency of teacher-student interaction (n=2269) in asynchronous, self-paced courses. The quality of the interaction was subdivided into three constructs: feedback, procedural, and social interaction. An increase in the quality and frequency of teacher-student interaction was correlated with an increased likelihood of course completion.

Similarly, the teacher was identified as the greatest source of variance in student learning in an earlier study undertaken by Hattie (2003). Excellence in teaching, as demonstrated by 'expert' teachers, was found to be the single most powerful influence on student achievement. Hattie says expert teachers identify essential representations of their subject, guide learning through classroom interactions, monitor learning and provide feedback, attend to affective attributes, and have a direct influence on student outcomes. Teacher influence can be measured in higher-levels of understanding of the concepts targeted in instruction, instruction that is more integrated, more coherent, and at a higher level of abstraction, than the understanding achieved by other students (Hattie, 2003, 2009). Clearly there are specific and measurable dimensions of teacher-student interaction that impact on student self-efficacy.

The discussion now moves to a description of the research methods applied to the first research question; that is, student perception of their learning when operating a robot. The self-efficacy of the students in this study was measured using surveys. The focus of the Survey items was the beliefs of students in their capabilities to produce designated levels of performance when learning to operate a robot remotely.

### **3.2:1 Data Gathering for Research Question 1**

Based on the techniques used by Alkharusi et al. (2014) and Pintrich (2002), two surveys were administered to collect information on student perception of their learning. The surveys were administered at the start (Appendix 1) and at the end (Appendix 2) of the study and were constructed of items that were chosen with reference to the self-efficacy beliefs and perceptions of the students, specifically their motivation and the learning strategies they used. Survey questions were designed to measure student motivation in terms of intrinsic and extrinsic goal orientation, their perceptions of the task value and their expectancy in terms of their beliefs about learning and their self-efficacy. Student learning was determined using three categories: cognitive, metacognitive, and resource management. The cognitive strategies used by students were interrogated using closed and open-ended questions to

determine their knowledge of robotics before and after their remote operation of the robot using the LDCR system. Questions were designed to measure the critical thinking of students as evidenced in their demonstrated knowledge of robotics and their skill acquisition as a result of remote operation of the robot. The metacognitive strategies used by students were identified through questions that focussed on their thinking about robots and remote operation of the robot, and their reflections on what they had learned about robots since joining the BSDE Robots Project 2014. Resource management strategies included questions about the scheduling and management of time by students to participate in the study, their physical location (onsite or off-site), and the peer-to-peer collaborative learning of students, teachers and experts in robotics.

The students in the current study (n=32) were a convenient sample of voluntary participants in the BSDE Robots Project 2014 and their involvement in the research study was in addition to their regular schoolwork. Data collection opportunities were restricted by student availability, due to their voluntary participation in the project and dispersed geographical locations. Surveys were therefore chosen as part of the research design because they enabled the time efficient and cost effective collection of data that would result in the best understanding of the research problem (Creswell, 2013). Two self-administered surveys were used to explore student perception of their learning when they operated a robot, and these underpin the first research question in the study. With interviewer bias negated through the use of self-administered surveys, and with the affordance of anonymity and privacy, it was anticipated that more candid responses would be elicited from the students. The use of self-administered surveys, it was expected, would yield data of higher validity that could then be standardised (Babbie, 2014).

In this study, the participants were students aged 9-12 years who, as part of their schoolwork, routinely provide written responses to questions. The collection of information through the use of surveys was, therefore, appropriate because it matched the curriculum demands placed on the students in terms of their literacy skill development. In addition, this type of data collection complied with the Queensland Department of Education, Training and Employment (DETE) policy on assessment. The policy requires teachers to use assessment *for* learning to monitor student knowledge, understanding and skills development, and to target their teaching to support the progress of students to meet learning goals. The use of assessment *as* learning is encouraged in situations where students are able to reflect on and monitor their own progress, and inform their future learning goals (DETE, 2015).

Two self-administered surveys were conducted over a six-month period. Respondents were required to work through a series of numerically listed questions. The survey design was based on surveys that were used in 2013 as part of the BSDE Robots Project 2013 when students operated the robot onsite, and prior to the trial of the LDCR system in 2014. The surveys used in the trial of the LDCR system in 2014 were adapted from the 2013 surveys. The aim in adapting the 2013 surveys was to design questions that could capture data in a more systematic and rigorous manner to produce data that could then be used to determine student perception of their learning before and after they had operated the robot remotely using the LDCR system. Each survey item required one response although it was possible for the number of responses to vary according to whether the question was open-ended or closed. The close-ended questions that were included in each survey required the respondent to choose between two responses (YES/NO) or from a list of possible answers in the multiple-choice questions. The open-ended questions allowed for a written response, in which the respondent determined the length and quantity.

Survey 1 was administered in August 2014 at the launch of the BSDE Robots Project 2014. The aim was to establish baseline data to establish student perception of their learning (Alkharusi et al., 2014), and identify the metacognitive strategies (Pintrich, 2002) students were applying to their learning prior to their operation of the robot using the LDCR system. Survey 2 was administered in December 2014 at the end of the study, with some late returns received in January 2015. Survey 2 was designed to collect information on student perception of their learning (Alkharusi et al., 2014) and identify the metacognitive strategies (Pintrich, 2002) they had used after they had operated the robot remotely *via* the LDCR system.

A comparison was undertaken of the results from Survey 2 with those from Survey 1 to indicate any changes in student perception of their learning about robots. Survey 1 consisted of seven questions, as shown in Table 3:

Table 3: Survey 1 Prior to use of the LDCR system by students

Number	Question
1	I've had previous experience with robots. YES/NO If YES, what type of robot?
2	What do you want to learn about robots in the BSDE Robots Project 2014?
3	What do you want the robot to do?
4	What type of terrain would you like to design for the robot to traverse?
5	Would you like to meet guest speakers who are experts on robots? YES/NO
6	How often would you like our group to meet for the Robots Project? Once every week Once every fortnight Once every month Once each school term
7	Where would you prefer to meet? Always on-site at BSDE Always virtually <i>via</i> Collaborate A mix of on-site (at BSDE) and virtual (Collaborate) meetings


The first question in Survey 1 was designed to establish the prior knowledge and learning about robots of the student participants. The question was dichotomous, that is, both closed-ended (YES/NO) and open-ended. Participants who answered 'YES' to Question 1 were asked to provide more detail in the form of a short written answer.

Questions 2, 3, and 4 were open-ended requiring short answer responses. Question 5 was close-ended (YES/NO), as were Questions 6 and 7, which were multiple-choice questions. In Question 2, students were asked what they wanted to learn about robots in the BSDE Robots Project 2014. This question sought to identify student perceptions of potential new learning prior to their experience of operating the robot remotely *via* the LDCR.

Similarly, Questions 3 and 4 asked students what they would like the robot to do and what terrain they would like to design for the robot to traverse. These questions, as with Question 1, were designed to collect information about what students hoped to learn about robots. Question 5 asked students whether they would like to meet guest speakers who are experts on robots. This question was intended to measure student interest in robots beyond the immediacy of the BSDE Robots Project 2014, and to inform planning for the project at school level. While Questions 6 and 7 were necessary in terms of the logistics of the project, they were essential in determining the availability of the students for the purposes of the research and information gathering.

The questions in Survey 2 were designed to measure student perception of their learning about educational robots, following their remote operation of the robot using the LDCR system. There were six questions in Survey 2, as shown in Table 4.

Table 4: Survey 2 Post-activity Survey

Number	Question
1	Please describe what membership of the BSDE Robots Project 2014 means to you.
2	I've operated the Lego NXT robot DCR14. YES/NO If YES, please describe your experience operating DCR14.
3	What do you know about DCR14?  Please label the parts of DCR14.
	
4	What did you learn about DCR14 as it moved around the robot field? For example: forward, right, left.
5	What else would you like DCR14 to do?
6	Please reflect on what you have learned about robotics since joining the Robots Project. This can include: Your on-site visits to BSDE to operate DCR14 Your long-distance control of DCR14 The information that we've shared about robots in our weekly online meetings Other research that you've undertaken on robots.

In Survey 2, the first question was designed to provide an opportunity for students to reflect on their learning about robots and for information to be identified that may be attributed to participation in the BSDE Robots Project 2014. It was an open-ended, short answer question with provision for students to respond in written form. Question 2 was dichotomous (YES/NO) and was used to determine whether the participant had operated the robot. Then

the participants who answered 'YES' were provided with the opportunity to give more detail, in the form of a short written answer, about their operation of the robot. These descriptions were expected to provide information about student perceptions of their learning about robots through their operation of the robot.

Question 3 was closed and required participants to label the parts of the Lego NXT robot on a diagram. This question sought to test student recognition of the main parts of the robot, and quantify knowledge acquisition. Question 4 was open-ended (short answer) and asked participants to reflect on what they had learnt about the robot as it moved around the robot field. Because Question 4 related directly to the remote control of the robot *via* the LDCR system, it was expected to yield data about student perception of their learning, and potentially the responses could inform all research questions in the study.

Question 5 was also open-ended (short answer) and was intended to measure any change in student perception of what they wanted the robot to do, as recorded in Survey 1 (Question 3), and what else they would like the robot to do following their experience of operating the robot. In Question 6, participants were asked to reflect more generally, through an open-ended (short answer) response, on their learning about robotics since joining the Project. The question encouraged participants to include details of their experiences in operating the robot on-site and remotely using the LDCR system for the purpose of comparison. Reflections on the sharing of information about robots during online meetings and the independent research on robots undertaken by participants, was also invited.

The analysis of the survey responses was undertaken using a thematic analysis applied to the open-ended questions. All responses were de-identified (answers were confidential) then collated for the purposes of the analysis.

### **3.3 Research Question 2**

What Science, Technology, Engineering and Mathematics (STEM) skills do students learn through robots?

In preparing to answer the second research question, the literature was explored to identify methodological techniques and approaches that can be used to identify and measure the STEM skills students learn through robots. The participants in this study were primary students (n=32) aged 9-12 years who were enrolled in a school of distance education. They operated in a digital environment where asynchronous and synchronous learning was blended. Students routinely used tools that enabled synchronous interaction with teachers and other students, and access to asynchronous web-based materials hosted on, Blackboard, the school's learning content management system. For the purpose of this study, two digital tools, blogs and video recordings, were investigated in terms of their efficacy as instruments for measuring STEM skill learning.

First, the use of blogs is discussed. A blog, or 'weblog', is defined here as a discussion or informational site consisting of discrete entries or 'posts' that is published on the World Wide Web. A blog is an online journal that can be continuously updated by users, in their own words, online (Matheson, 2004). According to Jimoyiannis & Angelaina (2012), blogs can be used for a variety of purposes. A blog can act as a forum where students discuss, share, and exchange information, thoughts, and ideas related to their course of study, operating more as



a collective or collaborative space than as an individual one. As such a blog can be used as a collaborative content-sharing space to support project-based learning activities.

In a review of empirical research on the use of blogs, Sim & Hew (2010) reported multiple benefits for students in higher education settings who engage in 'blogging'. Students who use blogs, it was found, are able to externalise their reflective reasoning through writing (Zeng & Harris, 2005), and develop insights into assumptions and beliefs that render or impede their judgments (Sharma & Xie, 2008). The externalised reflective reasoning and increased insight occurs because the blog prompts students to offer evidence, elaboration, and justification, and to critically evaluate solutions (Loving, Schroeder, Kang, Shimek, & Herbert, 2007). Blogs were also found to promote reflectivity through student engagement in active transactions among assumptions, motivations, and descriptions (Stiller & Philleo, 2003). Students were able to view their thought progression over time (Ellison & Wu, 2008), along with the growth of their individual knowledge base (Baggetun & Wasson, 2006).

While the literature clearly articulates the value of student participation in blogs, the challenge for researchers in terms of research methodology, is to quantify student engagement and learning in educational blogs. Three studies are cited that focus on the analysis of blogs. First, in research conducted by Yang (2009), a qualitative approach was applied to the analysis of a blog used by student teachers (n=43). The blog postings were analysed to determine whether students could critically reflect on what they had learned. Specifically, the analysis focussed on the type of reflection, the role of the teacher trainers in the process of blogging, and how a blog might promote critical reflection and enhance the effectiveness of a community of practice. Qualitative data was collected consisting of messages and comments posted on the blog by the students, and group reflective dialogues recorded by instructors in class meetings in relation to the implementation of the blogs during the course. Then an end-of-semester questionnaire was administered to each student. The blog postings were sorted into categories using a framework adapted from Ho & Richards (1993), with topics listed and analysed to identify aspects of their reflection, specifically whether it was descriptive or critical.

Using a similar approach, an analysis framework was developed by Jimoyiannis & Angelaina (2012), based on a Community of Inquiry (CoI) model and Social Network Analysis. Included in the evaluation was an investigation of the different ways that K-9 students (n=21) engaged in a blog-based project, in terms of their social and cognitive presence. The CoI analysis of blog postings indicated that integration of ideas and construction of meaning can be directly inferred from student participation, with students achieving higher thinking and cognitive levels through their adoption of different roles in the blog.

In more recent research, Xie & Sharma (2013) analysed the blogging behaviour of tertiary students (n=9) using a tool that combined the features of blogging with the ability to extract and manipulate concepts. Blog users were allowed to attach up to five keywords to each post and link the keywords on a concept map. Mental maps of the blog texts were produced with calculating nodes of high centrality (most talked about nodes and most connected nodes). Data analysis was undertaken using AutoMap and Organizational Risk Analyzer software with comparisons of student-generated keywords made against the mental map nodes. Findings suggested that two-thirds of the student-attached keywords matched the mental map nodes, indicating that the map analysis method can produce reliable indexes of a given text that may serve as anchor points for further content analysis.

### **3.3:1 Data gathering for Research Question 2**

In this study, students (n=32) were encouraged to contribute to a blog that was hosted within Blackboard, the school's learning content management system. The aim of the blog was to enable students to establish their social and cognitive presence (Jimoyiannis & Angelaina, 2012) as participants in the study. At the start of the study, students were informed by the teacher that they could use the blog to share information and ideas about robots with other project team members. Students were encouraged to tell each other what they already knew and thought about robots, and also what they would like to learn about robots. Thus, the blog was designed to engage students in reflective reasoning about robots, including quantitative skills, critical thinking, creativity, and behavioural and social skills, in parallel with disciplinary knowledge, as evidence of STEM learning (Australian Government, 2014c). The analysis of the blog data was undertaken using transcriptions of the blog postings made by the students. These were analysed using NVivo, a qualitative data analysis software package that enables textual data of the type gathered in the blog to be captured, read and manipulated. As suggested by Yang (2009), a thematic analysis of the transcriptions was undertaken and the information sorted into categories with keywords identified from STEM learning criteria (Xie & Sharma, 2013). Themes were created using keywords identified from STEM learning, then 'nodes' were established around specific blog postings, according to coding density. This thematic information was used to produce a set of statistics, based on the most talked about the most connected nodes, from which student social and cognitive presence was quantified. The answer, then, to the second research question was determined through an analysis of the blog data that was used to identify the STEM skills learned by students through robots.

The discussion will now turn to the third research question which investigates the learning by students when they operate a robot remotely using a LDCR.

### **3.4 Research Question 3**

What complementary skills do students learn when they operate a robot remotely using a Long Distance Control Robot (LDCR) system?

In answering the third and final research question in this study, the literature was interrogated to identify methodological techniques and approaches that were used to determine the complementary skills learned by students when they operated a robot remotely using a Long Distance Control Robot (LDCR) system. Ongoing developments that can be attributed to the advent of the Internet, along with the enhanced capabilities of personal computers and increased bandwidth capacity, have made remote learning through the Internet a convenient learning preference, leading to a variety of new interfaces and methods (Goldstain, Ben-Gal, & Bukchin, 2011). However, scant evidence exists in the literature on remotely controlled mobile robots (Kulich et al., 2013), whereas numerous articles report on remote laboratories with robotic arms that provide access to selected sensor equipment, such as sonars, infrared range finders, and cameras.

According to Kulich et al. (2013) this gap in the research comes at a time when mobile robotics is playing an increasingly important role in everyday life and becoming an inseparable part of many industrial applications. In turn the advent of robotics creates higher demands for the education of new professionals who must not only be able to operate

advanced robotic systems, but also understand robotic behaviours for design purposes. By way of solution, the authors designed the SyRoTek1 system that offered multiple robots (13) to tertiary student users (n=20) who had little programming experience and no previous experience with developing a robotic application. The system featured sensor equipment that provided access to the robots using laser range-finders with the potential to add new sensors as required, along with interfaces to robotic frameworks (Player/Stage and ROS) that are widely used in the robotics community.

In an introductory course designed to create an interest in intelligent mobile robotics, students were set the task of navigating a robot to create a map of the environment. The robots were operated remotely in the laboratory with students able to view the real behaviour of the robots in response to the applications they had designed, using a live video that was projected on the wall of the laboratory. Quantitative data was gathered from records of the version control system used by the students, along with their system usage and reservation statistics. Findings from this study suggested that the SyRoTek1 system allowed users to perform multi-robot experiments using robots equipped with rich sensor equipment, in a wide variety of scenarios.

Research undertaken by Goldstain et al. (2011) on the use of a remote learning interface focussed on the evaluation of the contribution of different interface components to the overall performance and learning ability of end users. The study evaluated components of the control method used for the robotic arm, the same approach mentioned by Kulich et al. (2013), and the use of a three dimensional simulation tool before and during the execution of a tele-operation robotic task. An experiment was designed to compare alternative interface designs for remote learning of robotic operation. A quantitative approach to the research methodology was taken with statistical data collected on the number of steps required by tertiary students (n=120) to complete the task, together with the number of errors during the execution of the task. An analysis was then made based on measurements of the rates of improvement demonstrated by the students during the task. The study concluded consideration needs to be given to the design of a remote tele-operation interface, in terms of the appropriate combination of components, if learning and teaching goals are to be achieved. The use of a preliminary simulation module was highly recommended. However, the integration of a virtual real-time presentation (VRTP) module into the interface was also recommended in situations where users could be provided with enough online access time to the robotic cell.

A study undertaken by Somander, Saylor & Levin (2011) analysed the responses of preschoolers (n=34) in their classification of living things by introducing them to robots that were engaged in goal-directed motion. Of relevance here is the age of the students and the use of both qualitative and quantitative research methodology. The study comprised two phases: robot exposure and test. In one situation, the students viewed a robot that appeared to move fully autonomously, while in another it was remotely controlled. Using a between-subjects research design, students were assigned to one of two conditions; that is, autonomous and controlled. The only point of difference was whether or not the students were given information about what made the robot move. In the autonomous condition, the robot moved with no evidence of a human controller, thereby giving the appearance of engaging in self-directed motion.

Conversely, in the controlled condition the robot moved only after an experimenter pressed buttons on a remote control, and this environment created the illusion that the experimenter was controlling the robot. Two experimenters interacted with the students, one to interview

them during the test phase using a series of questions, with the other experimenter controlling the robot from an adjacent room. Results were interpreted using a mixed multivariate analysis of covariance (MANCOVA) that was run on the proportion of 'yes' responses made by the students to representational, biological, and mechanical questions. While the findings from the study by Somander et al. (2011) give insights into the way preschool students make classifications using autonomous or controlled robots, of particular relevance is the use of a case study approach to the analysis of the findings through the combination of both quantitative and qualitative research data.

In answer to the third research question in this study, consideration was given to the selection of an appropriate instrument to measure the complementary skills learned by students when they operate a robot remotely using a LDCR system. The challenge in this study was to find a way to measure and record the complementary skills of students, that is, what they do and say when they operate the robot remotely. One technology, video recordings, will now be discussed within the context of data analysis that combines both numeric and textual data. Numerous studies make the case for the inclusion of video as a research tool. Having been influenced by the ethno-methodological tradition of conversation analysis, interpretive video analysis is described by Knoblauch & Schnettler (2012) as a powerful new tool for qualitative research. It provides unprecedented access to the minutiae of social interactions in real time, enabling the in-depth examination and sequential analysis of recordings. The focus for analysis is the interaction taking place in a certain social situation and this relies on additional contextual knowledge. The conclusion drawn in this thesis is that video analysis is a hermeneutic activity, in the sense that it requires a proper method of sociological understanding. It means the interpretation of the analysis needs to be supported with ethnography that recovers the typical knowledge required for actions in these settings. Provision must also be made in the interpretation of the video data, for the subjective perspective of the researcher, especially in situations where one person completes the analysis. Finally, given that interpretive video-analysis combines both video and ethnography, a new term 'videography' is proposed by Knoblauch & Schnettler (2012).

In a report by Abasi & Taylor (2007), the use of video data in adult literacy research, video data was analysed in an attempt to focus on collaborative learning in different types of adult literacy programs. While the study noted the use of video recordings resulted in rich, dense, permanent data that corresponded highly with reality, these outcomes were also found to complicate the analysis of the data. To overcome this complication, the video recording data was reduced, along with the development of a video analysis-coding grid that was used as an instrument for analysis. In reducing the recorded data, a structure was imposed on the video records to focus on what the researcher was looking for, and what was seen happening in the video records. In developing the video-coding grid, broad dimensions were established then broken down into specific behaviours or forms that were associated with sub-categories on an observational checklist. The grid was then used to view and code the interactions. Clearly, the literature supports the use of video recordings as a research instrument for the gathering of numeric and textual data.

### **3.4:1 Data Gathering for Research Question 3**

In this study, video recordings were used to identify and analyse the complementary skills learned by students when they operate a robot remotely using a LDCR. The students (n=32) were aged 9-12 years, and enrolled in a school of distance education. They were voluntary participants in the BSDE Robots Project 2014. From locations off-site, students joined online

sessions during which they learned to operate a Lego NXT robot remotely *via* the Internet using a LDCR system. First, students logged-on to the school's learning content management system to access a virtual classroom. They then linked to a website within a purpose-built LDCR system designed by Kanazawa Technical College, Japan, (Minamide et al., 2012). Using a software product, Blackboard Collaborate, video recordings were made of student operation of the robot *via* the LDCR system. The recordings were stored on the system for later review and analysis. *Verbatim* transcripts were created from the video recordings. Then the transcripts were analysed using NVivo, a qualitative data analysis software package, to determine the skill development of students in terms of their remote operation of the robot using the LDCR system. Coding density was established around the frequency of descriptive and explanatory references that were made by students as they operated the robot remotely using the LDCR system. Since the remote operation of the robot was a dynamic activity in which time is important, the video recordings have been used to measure the time taken by students, through a series of time trials, to drive the robot around the robot field. Then the data from the video recording transcript data and the time trial results was compared with the survey and blog data to triangulate results. The comparison and triangulation of the data was expected to provide a more complete set of findings than could be derived from the administration of one of the research methods alone.

## Summary

The focus of this study was the skilling of Australian students in digital technologies through the use of educational robots. The approach that was applied to the research methodology in this study was both inductive and deductive. Information was gathered from 'stories' in addition to numeric information (Creswell, 2013), enabling decision-making that was based on both quantities and qualities (Kaplan, 1964). The use of both qualitative and quantitative information was expected to result in a robust validation and verification of the knowledge claims around student engagement with digital technologies, specifically educational robots, with convergence across the data that would broaden, thicken, and deepen the interpretative base of the study (Creswell, 2003).

The data in the study was collected during 'virtual' off-site activities *via* the Internet when students operated the robot by remote control using the LDCR system. The sample population in the study was comprised of an experimental group of approximately 32 students (n=32) who were enrolled at BSDE during 2014. The students were voluntary participants in the BSDE Robots Project 2014. Students lived in a range of rural and remote and metropolitan settings throughout Queensland. They used the LDCR system over the Internet to operate the robot that was located in Brisbane. The group was drawn from the Year 6 and Year 7 cohorts (9-12 years of age), and included both male and female students.

The approach to data collection in this study was multivariate which is defined here as a statistical technique to examine the effect of many variables on a single outcome. Data was collected simultaneously during 2014 using Surveys, a blog, and statistical data gathered from video recordings of the remote operation of a robot. The data was identifiable during the collection of information because the names of individual students were recorded. However, for the purposes of data analysis, student names were changed to de-identify the data. Because participation in the project was voluntary, students were not assessed formally for the purposes of school reporting. Students were free to participate at a level that suited their time commitments and were also free to leave the project at any time.

The data analysis was undertaken using NVivo, a qualitative data analysis software package that enabled the data to be captured, read and manipulated to produce a set of statistics. Survey information was gathered from two surveys and the data was compared to determine the impact of the use of the LDCR system on the ability of students to use digital technologies, before and after their participation in the study. Evaluations were made of the validity or credibility, and the reliability or dependability, of non-numerical assessment. Then the data was converted to numerical form for statistical analyses. The final database, therefore, consisted of both quantitative (numeric) and qualitative (text) information.

In summary, the data was analysed to identify patterns in student learning about robots. Conclusions were drawn about student perception of their learning when they operated a robot, the STEM skills students learned through robots, and the complementary skills they learned when they operated a robot remotely using a LDCR system. In this study, an approach that holistically incorporated both inductive and deductive models through the combination of qualitative and quantitative methodology was applied. This approach was employed to bring reliability, validity and rigor to the analysis of the research data. In turn, it was expected that the data would confirm the evidentiary basis for the findings and the conclusions that have been drawn from this study.

## **Chapter 4**

### **Data Collection and Analysis**

#### **4.1 Introduction**

In this chapter, an analysis of the research data will be undertaken, and conclusions will be drawn from the data in answer to the three research questions posed in the study:

- When students operate a robot, what are their perceptions of their learning?
- What Science, Technology, Engineering and Mathematics (STEM) skills do students learn through robots?
- What complementary skills do students learn when they operate a robot remotely using a Long Distance Control Robot (LDCR) system?

The first research question will be investigated to determine the perception of students of their learning when they operate a robot, using data collected from surveys. Within the survey data, an investigation will be undertaken of student motivation (Bandura, 1986) and the learning strategies used by students, including their strategic knowledge, their knowledge about cognitive tasks, and their self-knowledge (Pintrich, 2002).

In answer to the second research question, the STEM skills learned by students through robots will be identified using data gathered from a blog. The blog data will be analysed to identify evidence of the development by students of social and cognitive presence (Jimoyiannis & Angelaina, 2012) and their ability to engage in reflective reasoning about robots, as evidence of STEM learning (Australian Government, 2014c), that is, their ability to integrate the disciplines of science, technology, engineering and mathematics (Kaufman, Moss, & Osborn, 2003). Evidence of STEM learning will be identified through statements within the blog data in which students refer to robot adaptations and robot operation, through student-to-student communications and statements that indicate STEM thinking.

For the third research question, the complementary skills learned by students when they operated a robot remotely using a LDCR system were identified through an analysis of data gathered from video recording transcripts. The transcripts were analysed using a structure (Abasi & Taylor, 2007) that included an in-depth examination (Knoblauch & Schnettler, 2012) of statements made by students in which they described and explained their learning of complementary skills related to the remote operation of a robot using the LDCR system. In particular, descriptive statements were identified in which students indicated their development of procedural knowledge and technical skills, and explanatory statements were examined to identify evidence of the development of metacognition by students.

The interrogation of the data, then, was expected to identify student perception to their learning when they operated a robot and the STEM skills students learned of robots, together with complementary skills learned by students when they operated a robot remotely using a Long Distance Control (LDCR) system. To retain anonymity, all student names were changed.

#### **4.2 Research Question 1**

In the first research question, information was gathered to determine student perception of

their learning when they operate a robot. Two surveys were conducted over a six-month period. Survey 1 was administered at the start of the study, in August 2014, to establish the motivation of students to learn to operate a robot. Survey 2 was administered at the end of the study in December 2014. The aim of the second survey was to identify the learning strategies used by students when they operated a robot, following their remote operation of the robot using the LDCR system. Thus, baseline data was established with Survey 1, prior to student usage of the LDCR system, with Survey 2 providing data that could be used to measure student learning. Eighteen students (n=18) responded to Survey 1. Seven students responded to Survey 2 (n=7). Six students responded to both Surveys. One student, Benjamin, responded to Survey 2 but did not respond to Survey 1 due to other school commitments. Two main themes were identified within the data around student motivation and the learning strategies used by students. These will now be discussed, beginning with student motivation.

#### **4.2:1 Student Motivation**

In this study, the self-efficacy beliefs and perceptions of students (n=32) were measured in terms of their motivation to learn to operate a robot. Given that student self-efficacy is influenced by, among other things, their prior experiences in the area of interest (Bandura, 1986) the students were asked about their experience with robots prior to joining the research study. Responses in Survey 1 indicated that 72% of students (n=13) had no experience, while 28% of students (n=5) had some previous experience with robots. The result from Survey 1 was relevant to the discussion of student motivation because all students in the study were voluntary participants and the data revealed the majority were completely new to robotics. While their voluntary participation could be correlated with their motivation to learn about robots, the time management skills demonstrated by the students was also relevant to the determination of their motivation. The issue of time management by students was important because participation in the study was above and beyond the regular school commitments of the students and thus, made demands on them in terms of their willingness to engage in additional learning in their own time. The involvement of the smaller percentage of students (30%), who had some previous knowledge of robots, was also used to measure motivation because this group, through their participation, demonstrated an ongoing interest in the subject; that is, a willingness to learn more about robots than they had previously known.

Further indications of motivation became evident in the Survey 1 data when students were asked what they would like to learn about robots, with two main themes emerging. The majority of students, 72% (n=13), stated that they wanted to learn how to build, program and control robots, and 44% of students (n=8) wanted to learn how robots work and their uses. The data, then, suggested the students in the study had observed others completing the same or similar tasks, and that their expectations in relation to the execution of the tasks were positive (Bandura, 1986). Two students (n=2) were more effusive and less specific in their responses stating that they wanted to learn ‘everything I can’ and ‘whatever I can’ about robots, statements that were suggestive of high levels of enthusiasm that were equated with motivation.

Additionally, indications of the motivation of students to learn about robots emerged when they were asked what they would like the robot to do. Students typically described manoeuvres for the robot to perform and interactions they would like to have with the robot. Students described manoeuvres in which the robot would ‘do what my code tells it to do’, ‘walk or have wheels to move’, ‘dance,’ ‘jump’, ‘fly’, ‘move a ball’, ‘drive really fast’, ‘race’, ‘four-wheel-drive’, ‘maybe have an arm so it could grab things’, ‘elevate while



moving', 'go around a maze', and for the robot 'to be able to be fully-controlled from a safe distance'. Interactions with the robot included 'speaking', 'interacting with humans', 'move like a human so it can do simple tasks such as helping me with things, doing chores, being my personal maid, picking up and carrying things, and cleaning', and 'giving me hints on games'. Similarly, when students were asked to envisage the type of terrain they would like to design for the robot to traverse, their responses were both highly creative and descriptive, criterion that can be correlated with motivation. For example, students suggested terrain such as 'sand', 'grass', 'forest', 'rocky', 'pebbles', 'snow', 'water (like a submarine car)', 'something slippery', 'rough and smooth', 'tunnel', 'caves', 'mountains', 'flat or hilly terrain with a little hill climb (but not too big)', 'up and down ramps', 'tiles', 'train tracks', and 'drive around the school'.

Then, when asked if they would like to meet guest speakers who were experts on robots, there was a unanimous response, 100% (n=18), from students. While the unanimous response provides further confirmation of the motivation of students to learn about robots, it is a clear indicator of their level of motivation because it was an emphatic declaration that they wanted to learn from experts in the field. The frequency with which students indicated they would like to meet to learn about robots can also be interpreted as a measure of motivation. When given four options that included meetings conducted once per week, once per fortnight, once per month and once per term, the majority of students, 55% (n=10), chose to meet weekly, with 35% (n=6) choosing fortnightly meetings. In total, 90% (n=16) of students chose to meet on a highly regular basis, which was also indicative of high levels of enthusiasm for the subject and their high enthusiasm was correlated with high motivation.

Finally, when asked where they would prefer to meet to learn about robots, the data revealed that 72% (n=13) of students preferred a combination of on-site (at BSDE) and virtual meetings, that is, using a blended learning model (Hastie et al., 2010). This preference for blended learning meant the majority of students were willing to travel to BSDE for on-site meetings, or participate from off-site *via* the Internet, using the virtual classroom on the school's learning management system. Both modes of participation required time and effort that can be directly correlated with enthusiasm and motivation.

For some students, participation on-site involved a journey of considerable distance. For example, on occasions Cameron undertook a four-hour journey by road from his cattle property in Western Queensland to drive to BSDE to operate the robot. For other students like Jenny who lived in North Queensland, the distance was too great and thus precluded her from on-site activities; however, Jenny was able to participate at high level from off-site *via* the Internet using the virtual classroom, and subsequently the LDCR system. Parental perception verified the high levels of motivation of students who participated from off-site, as evident in this statement from Marty's mother, in which she said,

*Marty has wholeheartedly engaged with the robot project and plans days to weeks ahead for the sessions because he enjoys them so much. He is doing distance education because we are travelling remotely so sometimes our Internet coverage is patchy. If there is a robot session coming up, Marty makes sure we travel to an area with Internet coverage so he doesn't miss the session!*

At the end of the study, when students described their experiences of remote operation of the robot, their responses were ebullient and included statements such as 'exciting and amazing', 'great fun' and 'an awesome experience', as encapsulated by twelve year old Benjamin who

stated,

*When we first got the robot we had to go into school to drive him, but now we can drive him from off-campus, just one small step in his development that I have been able to witness and be part of.*

Given that the majority of students, 72% (n=13), had stated at the start of the study they wanted to learn how to build, program and control robots, it appears their expectations of positive experiences in relation to the execution of tasks had been met (Bandura, 1986, 1994, 1997). As a consequence of their actions, they had reached their goal; that is, the successful remote operation of a robot using the LDCR system, and developed greater confidence in their learning about robots (Hemmings & Kay, 2009). The effort the students had invested in learning about robots and the affect of this effort on their achievement (Moriarty, 2014) was a strong measure of their motivation.

The survey data, then, indicated the students in this study developed a high level of motivation to learn about robots, and maintained this high motivation for the duration of the study. In addition the data implied that distance did not impact negatively on the motivation of the students. Distance was not a barrier but instead presented an opportunity for these students to learn about robots because they had learned how to operate a robot remotely.

#### **4.2:2 Learning strategies used by students**

The strategies used by students to learn about robots will now be investigated. Three categories of learning, strategic knowledge, knowledge about cognitive tasks, and self-knowledge (Pintrich, 2002), will be examined. Strategic knowledge will include examples of student knowledge of their general strategies for learning and thinking. Specifically, instances in which students made connections between and among content elements will be identified as evidence of their organisational learning strategies, and hence their metacognitive function (Weinstein & Mayer, 1986).

Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge, will focus on 'what' and 'how', as well as when and why students used various strategies, as proof of learning expertise. Self-knowledge will be interpreted as demonstrations by students of their knowledge about the self (the person variable) in relation to both the cognitive and motivational components of their performance, following their remote operation of the robot. Self-knowledge will also include evidence of student knowledge of their strengths and weaknesses, their awareness of the breadth and depth of their own knowledge base, and their awareness of the different types of strategies they are likely to rely on in different situations (Pintrich, 2002). The discussion now turns to an examination of strategic knowledge, the first category of learning.

##### **4.2:2(a) Strategic knowledge**

In determining strategic knowledge, students were asked, in Survey 2, about their learning and thinking following their remote operation of the robot using the LDCR system. The data in Survey 2 revealed numerous examples of the connections students had made, throughout the study, between and among their learning following their experiences of remote operation of a robot.

A description of the steps involved in logging-on to the LDCR system and how to operate the robot remotely, exemplifies the connections made by Cameron in his learning. He recounted the steps, saying,

*To make DCR14 (the robot) move around the robot field we went through Google chrome and we hit the button that we wanted the robot to go. For example, if we wanted it to go right, we hit the right button and if we wanted it to go forward we hit the forward button.*

Other students demonstrated strategic knowledge through the connections they had made between the technical aspects associated with remote operation of the robot. Max, for instance, commented on the changes he had observed in the control of the robot following modifications that had been made to the code, saying, *'Driving the robot at first was a little bit hard, but the changes that were made in the control made it easier to drive.'* Similarly, Jenny who lived in North Queensland made linkages between her physical location and the location of the robot, stating: *'I had great fun controlling him (the robot), it was like controlling something really close but it was far away.'*

Then, when asked what they had learned about the robot as it moved around the robot field, students typically made cause-and-effect associations between their operation of the robot and its movement. For example, Peter described the robot as *'nimble for its size'*, and John described his experience of controlling the robot remotely, saying, *'and I have learnt to control DCR14 and not let him crash into the walls.'* Similarly, when Jenny said, *'I learnt that you could move him (the robot) around, even you could do 360s,'* she demonstrated the connections she had made between her actions and the manoeuvres the robot could perform.

Survey responses of this type demonstrated that students had developed considerable strategic knowledge (Pintrich, 2006) in terms of the general strategies they had used for learning and thinking about robots, and had used this strategic knowledge to make connections between and among their learning following their remote operation of a robot. Student knowledge about cognitive tasks will now be discussed.

#### **4.2:2(b) Knowledge about cognitive tasks**

Student knowledge about cognitive tasks was investigated through questions, in Survey 2, that focussed on 'what' and 'how' they knew about robots, as well as when and why they used different strategies (Pintrich, 2002), as proof of the expertise they had developed about robots following their remote operation of the robot using the LDCR system. As an example, students were asked to label a diagram and name the component parts of a robot to demonstrate 'what' they knew. The process of labelling meant they had to recall information, and actively search their memory to retrieve relevant information about the Lego NXT robot used in the study. Students scored 100% accuracy (n=7) on this task.

Then, when asked at the end of the study what else they would like the robot to do, students demonstrated the expertise they had gained through descriptions of new manoeuvres they envisioned for the robot. Their responses included references to the robot's component parts that suggest students had applied their knowledge of the robot, that is, their knowledge of 'what' with 'how', in new and innovative ways. For instance, when Cameron said, *'I would like DCR14 to have a stronger engine and be able to do jumps'*, he demonstrated his knowledge of 'what' he wanted the robot to do and 'how' this result could be achieved.

Similarly Max commented that, *'If DCR14 had arms, we could make him pick up some objects,'* while Jenny asked, *'Instead of rolling around, why not make him walk?'*

The data also revealed evidence of the development of student knowledge of 'when' and 'why' they had used different strategies to learn about robots. For example, Peter compared the control of the robot before and after modifications had been made with the code, demonstrating his knowledge of when and why to use different codes saying,

*DCR14 goes around his 'track' faster than I would have expected! I prefer the previous way of driving, where you have to press the stop button for driving forwards and backwards, but the other way for when turning.*

In another example of 'when' and 'why' thinking, Max described the latency (or delay) experienced when using the LDCR system, saying, *'I learnt that there were a few seconds delay when I pressed stop.'* Then, when John stated, *'I would like our advanced little friend to be a life-sized Humanoid so he would be able to interact and roam freely around the school,'* he had envisaged human-machine reciprocity. John's statement demonstrated the expertise he had developed and the ways he had applied his knowledge of the remote control of robots, that is the 'what' and 'how', as well as 'when' and 'why' to use these different strategies (Pintrich, 2002). The discussion now moves to student self-knowledge.

#### **4.2:2(c) Self-knowledge**

Student self-knowledge was examined, in Survey 2, through a series of questions that asked students to reflect on what they had learned about robotics since joining the study. The data was interrogated to reveal evidence of student knowledge of their strengths and weaknesses, their awareness of the breadth and depth of their own knowledge base, and their awareness of the different types of strategies they would use in different situations. A further consideration was the effect of social presence on the self-efficacy perceptions of the students in an online setting (Zhan & Mei, 2013).

An insight into student knowledge of their strengths and weaknesses can be found in a statement by John in which he reflected on the challenges he had encountered in learning about robots saying, *'I have discovered that it is not the easiest task to build a robot, nor is it to program one, however it certainly is a very interesting and diverse task to undertake to learn these skills'.*

Students demonstrated their awareness of the breadth and depth of their own knowledge base in statements such as one made by Peter in which he said, *'It is possible to control a robot over the Internet autonomously without too much work.'* Similarly, Jenny gave an insight into her knowledge base, saying, *'I have learned a lot about Lego NXT Robots and I really liked learning how to operate them and I enjoy working with the Robots Project Team.'*

John's self-knowledge was evident in his descriptions of his skill acquisition when he said, *'I have learnt to control the robot and the technological amazements it holds.'* In addition, he demonstrated an awareness of technology in the broader sense that indicated higher order thinking. Similarly, Benjamin demonstrated a high level of metacognitive function and profundity beyond his years when he stated, *'I learned that technology is getting more and more advanced as we speak and unless more children are exposed to these advancements early on in their education then they could well be left behind in the technology race.'*

Within the data, the issue of social presence emerged in numerous responses from students. Cameron's statement highlighted the issue of social presence when he described his experiences, as an isolated student, living in a remote location in Western Queensland. He stated,

*I have learnt that distance does not stop me from participating in these activities even though I am four hours away from the robots. I also like the interaction with other children as living so far away makes it hard to get to all the activity days.*

A statement made by Joshua, another isolated student, provided further evidence of the effect of social presence on self-efficacy perceptions. Joshua said, *'I loved meeting all the amazing people and friends who had so much knowledge I can learn from.'* Enhanced self-efficacy, as demonstrated here, is equated with the development of cognitive knowledge.

In summary, the first research question was investigated using data from two surveys that examined student perception of learning when they operated a robot. Within the data, two themes emerged that were used to determine student perception of learning. The first theme was formed around the motivation of students to learn about robots, and the second around the strategies used by students to learn about robots. Findings suggested that, when students learned about robots, the majority of them demonstrated high levels of motivation and developed enhanced self-efficacy (Bandura, 1986, 1994, 1997). Moreover, most students demonstrated greater proficiency in their use of metacognitive strategies; that is, their use of strategic knowledge, knowledge about cognitive tasks, and self-knowledge (Pintrich, 2002).

Enhanced metacognitive capability was evidenced in statements made by students about the challenges they had encountered when learning to build and program robots, together with demonstrations of their increased technical knowledge and skills. Positive outcomes were also identified in terms of the cognitive and social presence (Jimoyiannis & Angelaina, 2012) and the self-efficacy developed by students in an online setting (Zhan & Mei, 2013), outcomes that were directly attributed to participation in online and blended learning sessions about robots. The findings, then, indicated that when the students in this study learned about robots, the majority of them developed positive perceptions of their learning. The second research question will now be discussed.

#### **4.3 Research Question 2**

For the second research question, information was gathered to determine what STEM skills students learn through robots. Throughout the study, students (n=32) were encouraged to contribute to a blog that was hosted within Blackboard, the school's learning content management system. The aim of the blog was to enable students to establish their social and cognitive presence (Jimoyiannis & Angelaina, 2012) and engage in reflective reasoning about robots, as evidence of STEM learning (Australian Government, 2014c). STEM is discussed here in terms of a 'metadiscipline', that is, a discipline based on the integration of other disciplines, namely science, technology, engineering and mathematics (Kaufman et al., 2003).

An analysis of the data gathered from the blog was undertaken using NVivo, a qualitative data analysis software package. Themes were created using keywords identified from STEM learning that were indicative of the development by students of deep knowledge of a subject, creativity, problem solving, critical thinking and communication skills (Australian

Government, 2014c). The blog data was then interrogated to find evidence of student thinking and behaviours that could be correlated with these themes, and ‘nodes’ were established around specific blog postings, according to coding density. Based on the most talked about and the most connected nodes, a set of statistics was produced from which student social and cognitive presence was quantified. The data from the blog will now be discussed.

During the study, a total of 283 blog postings were made by thirteen students (n=13), as shown in Figure 3.

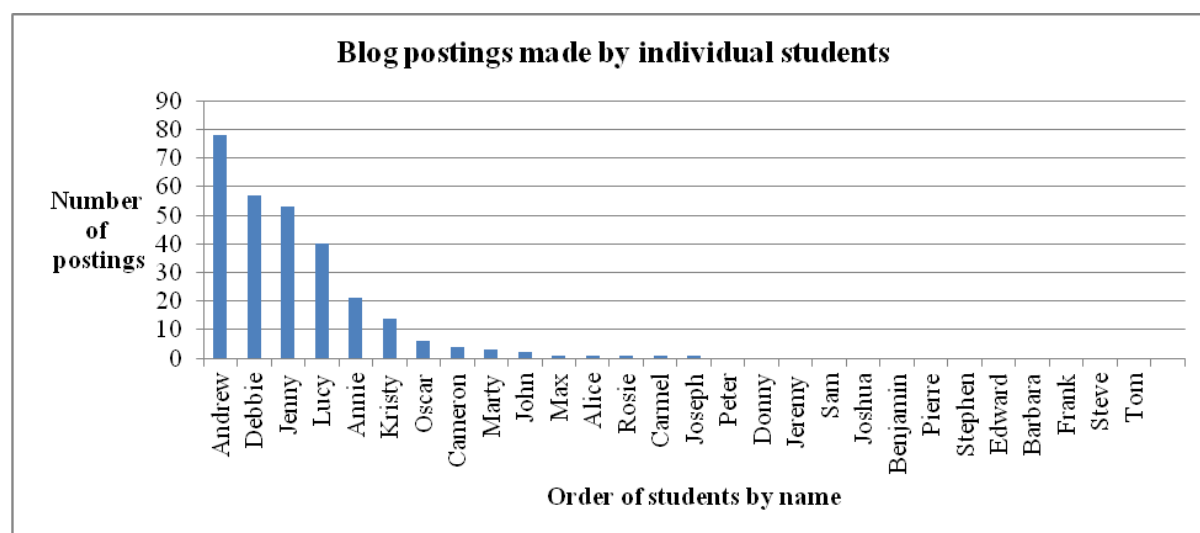


Figure 3: Graph showing the number of blog postings made by individual students

Access to the blog was unrestricted throughout the study; however, the frequency table showed a wide variance in the number of postings made by students. While factors that may have influenced student usage of the blog were not investigated, possible explanations may include the physical and social isolation, time commitments, literacy levels and the preferred modes of communication of students. Further research may explain the variation in blog usage amongst the students in this study, and the findings extrapolated to students in other distance education settings.

Within the blog data, the highest coding density was identified around postings that evidenced communication between students, demonstrations of their STEM thinking, and references they had made to the Lego NXT robot (DCR14) that included suggested adaptations of the robot and shared perceptions of their experiences of remote operation of the robot. Four nodes were then created within NVivo for the purposes of analysis. These were labelled ‘robot adaptations’, ‘robot operation’, ‘Student-to-Student communications routine’, and ‘STEM thinking’.

The node, ‘Student-to-Student communications routine’, was used to code responses from students in which they had engaged in more general discussions with each other, for instance where they had said ‘Thanks’ or ‘Great idea!’ A data sub-set, labelled ‘Student-to-Student communications higher level’, was created within the node ‘Student-to-Student communications routine’ to determine the number of references students had made to higher level thinking about STEM topics. The blog data was then analysed using these nodes, as shown in the Table 5.

Table 5: Blog data nodes

Nodes	Sources	References
Robot adaptations	12	62
Robot operation	6	20
Student-to-Student communications routine	13	256
- Student-to-Student communications higher level	5	42
STEM thinking	13	101

As shown in Table 5, a total of 439 references were recorded. The greatest number of references (256) made by students, were around ‘Student-to-Student communications routine’, and the number included a sub-set of references (42) that were identified as being representative of ‘higher level’ communications. This number was followed by references to ‘STEM thinking’ (101), then ‘robot adaptation’ (62) and ‘robot operation’ (20).

The references made by individual students to each node were also quantified in the blog transcripts. These are listed in Table 6.

Table 6: References made by students

Name	Nodes	References	Percentage
Andrew	4	110	25.0%
Jenny	4	91	20.7%
Debbie	4	58	13.2%
Kristy	3	36	8.2%
Cameron	4	23	5.2%
Lucy	3	22	5.0%
Rosie	3	21	4.8%
Annie	4	20	4.6%
John	4	18	4.1%
Alice	3	13	3.0%
Oscar	3	11	2.5%
Marty	2	10	2.3%
Max	3	6	1.4%

As shown in Table 6, a total of 439 references were made by students and, on average, students made 34 references. The greatest number of postings came from Andrew (110), representing 25% of the total, followed by Jenny (91) who made 21% of the postings. When combined, the postings made by these two students comprised 46%, or almost half, of the total references. However, the majority of references, that is 54%, were sourced from blog postings (238) that had been contributed by the other eleven students. The least number of references (6) were from Max, who contributed 1% of the postings. The discussion now moves to an analysis of the results by node, with examples drawn from the postings of individual students.

#### 4.3:1 Robot adaptations

In determining what STEM skills students had learned through robots, blog postings in which students had suggested robot adaptations were examined to provide evidence of ‘designed

solutions'; that is their design thinking and design processes (ACARA, 2015b). In particular, the data was interrogated for statements in which students had demonstrated the use of strategies for understanding design problems and design opportunities. The interrogation of the data included blog postings where students had articulated their visualisation and generation of creative and innovative ideas, and analysed and evaluated their ideas to best meet their criteria for success and planning of adaptations in relation to the robot and its operation.

The data revealed that 14% (62) of the references made by students were about robot adaptations. Examples of adaptations to the robot that were indicative of the designed solutions proposed by students included one from Debbie, in which she said, *'I was thinking that maybe we could lift DCR14 and put suspension so he can go over, up and down rocky areas without much trouble.'*

Design thinking and processing was also evident in statements in which students described the actions that the robot would perform as a result of adaptations they had visualised. For instance, Max said, *'I was just thinking as an idea for DCR14 that maybe we could make arms and fingers so that it can pick up objects. I was also thinking that maybe we could add a camera to him so that you can take pictures remote-controlled.'* Andrew proposed a test of the weight-bearing capability of the robot that could be analysed and evaluated over time, saying, *'I have thought of some tasks for DCR14. Maybe we could put something heavy on him and keep progressing by making the object heavier and heavier each time and then we see what happens.'*

Adaptations to the robot, such as those proposed by Andrew, Max and Debbie, indicated students had devised design solutions as a result of their engagement in design thinking and design processes, behaviours that are consistent with STEM skill learning.

#### **4.3:2 Robot operation**

Further evidence was established within the blog data of the skills learned by students through robots, in statements that indicated their development of deep knowledge, or deepening knowledge of STEM (Australian Government, 2014c). The descriptions made by students of their operation of the robot, either onsite at BSDE or remotely using the LDCR system, and their reflections on those experiences were identified and equated with the development of STEM knowledge, and the STEM skills associated with the physical operation of a robot.

References to robot usage within the blog data were made in 5% (20) of the posts. While the number of references to robot operation was small compared to the references recorded against the other nodes, the quality of student responses indicated high-level STEM skill learning. For instance, students frequently used STEM thinking and terminology to report information about their physical operation of the robot.

Pierre, for example, measured the latency (or delay) between the time he clicked the control button and the time the robot moved, and then shared this information in the blog saying, *'When I drove DCR14, the reaction speed was around 1.3 seconds.'*

Likewise, Jenny reflected on her experiences when operating the robot remotely before and after modifications had been made to the control buttons, stating, *'I find it easier to drive*



*DCR14 with just holding down the button and not having to click all the time, and I'd also like to say, it has been a lot of fun controlling DCR14 remotely.*' Then, when students were asked to comment on the speed of the robot when they operated it, Annie recalled that it was *'quite fast'* on one occasion but slower the next time. She commented that *'it does use more battery power'* to go faster, then added, *'I'd prefer longer driving than faster!'*

Statements about robot operation, while fewer than those for other nodes, were nonetheless indicative of the development by students of deep knowledge about robots. As a result of their remote operation of a robot, students demonstrated they had developed highly technical knowledge about robots, and this deep knowledge about robots can be equated with STEM skill development.

### **4.3:3 Student-to-Student communications**

In establishing the STEM skills learned by students through robots, the communication between students within the blog was examined. In particular, statements made by students that gave an indication of their attitudes, beliefs, self-esteem, self-confidence, and motivation (Zollman, 2012) were identified as a measure of student self-perception of their STEM skill learning through robots.

Within the data, the greatest number of references was made to student-to-student communications (256), representing 58% of the total. When analysed, the data revealed that the majority of the communications between students were 'routine', that is, conversational in nature. However, these 'routine' communications between students revealed strong evidence of the development of student attitudes, beliefs, self-esteem, self-confidence, and motivation in relation to robots. A statement made by Jenny suggested she had developed a highly positive self-perception in relation to her learning about robots:

*I would just like to comment on controlling DCR14 remotely. I think it was absolutely fun! I hope everyone gets the same enjoyment of controlling him. I just love the ideas that everyone has come up with. I hope that everyone has a GREAT time with DCR14. It's very exciting that we can control DCR14 remotely and many thanks to the Japanese Professors for getting us the NXT Lego Robot.*

Similarly, Annie articulated high levels of self-esteem, self-confidence, and motivation in relation to her learning about robots, saying, *'In Year 6, the Robots Project was by far my favourite subject, so I share your enthusiasm! The Robots Project is invaluable. How many schools/students can say they've had real life robot interaction?'* Then, when Andrew said, *'Hello this is DCR14 speaking. Thank you for all the positive comments about me,'* he seemed to indicate that he had assumed the persona of the robot.

Higher-level communication about STEM topics was determined through an in-depth analysis of student communications within the blog data. Postings that demonstrated higher-level thinking about STEM were coded to the data sub-set, 'Student-to-Student communications higher level'. The analysis indicated students had made 42 references to higher level thinking about STEM topics, that is, 16% of the total (256) student-to-student communications.

An example of communication at a higher level was identified in a blog conversation that John had started. He said, *'I was thinking that somehow, maybe we could increase DCR14's*

*speed.*’ Annie replied, saying, *‘Yeah, right now, he’s especially slow. I’ve seen them put his speed up. He is really fast then!’* Then Lucy suggested, *‘Maybe we can control the speed with the arrows on our keyboard?’* Subsequently, the modification suggested by Lucy was adopted and students were able to operate the robot using the arrow keys on their keyboards.

Similarly, Jenny demonstrated communication at a higher level through a blog posting in which she proposed another modification to the robot. She said: *‘What if we could make DCR14 high, so we put in a higher suspension and then it would be easier to pick him up and see underneath him, in case a problem occurs?’* Debbie responded saying, *‘Sounds great, Jenny,’* and Andrew endorsed Debbie’s response saying, *‘That’s a really good idea.’*

Higher-level communication was also demonstrated by Debbie, who suggested the stationary cameras around the robot field could be modified so they would adjust automatically to track the robot. Jenny responded saying, *‘Debbie that’s a BRILLIANT IDEA!! Great work with the great ideas’*, and Lucy concurred saying, *‘Yes, REALLY good idea.’* While the responses to Debbie from other students were routine, they demonstrated the highly collaborative nature of student-to-student communications in the blog. The STEM thinking of students will now be discussed.

#### **4.3:4 STEM thinking**

As evidence of the STEM skills learned by students through robots, instances of STEM thinking were identified in postings where students had made reference to, or discussed, STEM concepts that demonstrated STEM literacy. That is, STEM literacy was demonstrated in their ability to identify, apply, and integrate concepts from science, technology, engineering, and mathematics to understand complex problems and to innovate to solve them (Balka, 2011).

References made by students to STEM thinking comprised 23% (n=101), of the total in the postings in the blog data. Numerous references were found in the blog data that demonstrated the ability of students to identify, apply, and integrate STEM concepts. Alice and Lucy demonstrated an example of the application by students of their knowledge of STEM, when they proposed engineering solutions to overcome a problem they had identified. Alice said, *‘I thought it might be fun if we could make like a floatation device so that DCR14 can travel over water without getting wet.’* Then Lucy responded saying, *‘We have to make a bridge that is durable over water and has enough strength to hold up DCR14 as well as support DCR14 if we accidentally control it straight off!’* Similarly, evidence of STEM thinking was found in a statement made by Jenny, in which humanoid functions for the robot were envisioned. She said, *‘I think DCR14 can talk back to us when we say "Hi" or "Hello" to him. It would be cool if he could walk, talk and act like a human.’*

In a blog posting made by Marty, he shared information on how to build a robot, saying, *‘If you are interested in robot building try using Arduino and you can get them at Jaycar. They have a whole range of add-ons for them. You can order online and they deliver them to almost any bit of Australia.’* While Marty’s posting gave an insight into his individual STEM concept development, his posting had the potential to influence the STEM development of fellow students because, in effect, Marty was teaching his classmates about STEM.

Similarly, Andrew shared his STEM thinking with classmates in a blog posting in which he described the independent research he had undertaken on the control of the robot. He stated,

*'I did some research and figured how to control DCR14 with a PS3 controller; it is actually possible for this to work, here is the evidence. Feel free to check out the video for the final results of this project in action! <https://www.youtube.com/watch?v=-NCEqi-qMsc>*

In another example, Lucy suggested to Jenny she could consider a career in robotics. Lucy said, *'WOW!! Have you looked into working in the robotics area?'* Jenny replied, *'No Lucy, I have not, but I might like to when I'm older and in University.'* Then Debbie added a comment saying, *'Well at least you will get a head start.'* Jenny agreed saying, *'Yes, I will get a head start because we are currently working with a robot.'* The statements made by Debbie and Jenny, in which career choices involving robots were discussed, clearly indicate students were engaging in STEM thinking.

To summarise, the second research question used data collected from a blog to identify the STEM skills learned by students through robots. The data showed the majority of students in the study had identified, applied and integrated concepts from STEM, specifically STEM concepts related to robots, and used these STEM concepts to understand and solve complex problems about robots (Balka, 2011). They had engaged in STEM learning that included creativity, problem solving, critical thinking and communication skills (Australian Government, 2014c). For instance, students had designed adaptations for the robot, and envisioned humanoid functions. They had used quantitative skills to measure and critically evaluate latency and speed issues associated with the operation of the robot. Students had also undertaken independent research to modify the control and operation of the robot, and proposed tests of the capability of the robot that could be analysed and evaluated over time. The data revealed that students had considered further study and careers in robotics. These findings suggest that, through robots, the students in the study had learned STEM skills that matched the criterion for STEM learning as articulated by the Australian Government (2014c). The third research question will now be discussed.

#### **4.4 Research Question 3**

For the third research question, evidence was gathered from video recordings to determine the complementary skills students had learned when they operated a robot remotely using a LDCR system. Using transcripts from the video recordings that were created to provide a structure for analysis (Abasi & Taylor, 2007), an in-depth examination was then undertaken (Knoblauch & Schnettler, 2012) to focus on the identification of any complementary skills learned by students through their remote operation of a robot using the LDCR system.

During the study, students (n=32) were encouraged to join online lessons, using a virtual classroom, to learn to operate the robot remotely using the LDCR system. The lessons were recorded and stored on Blackboard, which was the school's learning management system. Verbatim transcripts were created from three (3) transcripts of recordings in which fourteen (14) students had used the LDCR system to operate the robot remotely. These three recordings were made in November 2014 at the end of the study and were selected because it was considered to best demonstrate the mastery that students had developed in their use of the LDCR system. On average, each video recording lasted sixty minutes. For the purposes of analysis, keywords were identified within the transcripts from themes associated with robot operation and the LDCR system. Then 'nodes' were created within NVivo, a qualitative data analysis software package, to determine the coding density around these themes. Statements from the transcripts were coded to two nodes, labelled 'LDCR system descriptive' and 'LDCR system explanatory'.

The first node, ‘LDCR system descriptive’, was used to record the number of statements in which students had described their use of the LDCR system to control the robot remotely. The statements that were coded to this node were selected from instances where students had described ‘what’ they had done and ‘when’, as they were learning to operate the robot remotely using the LDCR system. These were statements of fact; first-hand accounts of what students reported were happening with the robot at the time.

The second node, ‘LDCR system explanatory’, was used to record the frequency with which students had made explanatory statements about their control of the robot using of the LDCR system. Statements coded to this node demonstrated instances where students had explained ‘how’ and ‘why’ they were learning when they used the LDCR system to operate the robot remotely. The two nodes, ‘LDCR system descriptive’ and ‘LDCR system explanatory’, were then used to code references from the video recording transcripts, as shown in Table 7.

Table 7: Video recording transcript data

Name	Sources	References
LDCR system descriptive	3	128
LDCR system explanatory	3	64
Robot adaptations	12	62
Robot operation	6	20
STEM thinking	13	101

As shown in Table 7, the data revealed the majority of references made by students in relation to their remote operation of the robot when using the LDCR system, were ‘descriptive’ (128), with ‘explanatory’ statements (64) comprising half that number. The 2:1 ratio between the number of descriptive and explanatory statements may be due to the fact that the video recordings capture the early stages of student skilling in the use of the LDCR system for remote operation of a robot. Students were fully occupied during the study with learning how to operate the robot remotely using the LDCR system, and they made numerous references to ‘what’ they were learning. Possibly, they were less able to explain ‘why’ they had learned new skills. A longitudinal study would need to be undertaken to determine whether students developed greater capacity, through more practice and over time, to explain their learning when operating a robot remotely using the LDCR system. The descriptive statements of students, identified in the video recording transcripts, will now be examined.

#### **4.4:1 Student descriptions of their learning**

Within the video transcript data, an investigation was undertaken of the ‘descriptive’ statements made by students to establish ‘what’ students had learned when they operated the robot remotely using the LDCR system. Specifically, the investigation involved the identification of statements where students had described the procedures involved in using the LDCR system, and the technical skills they had used to operate the robot using the LDCR system.

##### **4.4:1(a) Procedural knowledge**

To successfully operate the robot remotely, students were first required to develop procedural knowledge of the LDCR system. Having joined the virtual classroom, students needed to

learn to follow a specific set of procedures, in sequence, to gain access to the LDCR system. Students were required to maintain a connection to the LDCR system, or reconnect if their connection was lost, and then log-out of the system when they had finished. In learning the procedures associated with the LDCR system, students needed to work in collaboration with teachers, students and the technician and the collaboration required students to develop their communication and social skills.

Part of the procedural knowledge in relation to the LDCR system involved students learning to take turns at using it. Various approaches were used throughout the study to ensure equitable turn taking when students were operating the robot remotely. For instance, students were allocated turns in the order they had arrived in the session, by alphabetical order according to their name, and through collaborative negotiation to accommodate individual circumstances. For example, when John could not establish his connection, Benjamin volunteered to step-in until John was ready, saying, *'I'll take John's turn because his isn't working.'* In another example, Pierre was allocated the last turn during a session and commented, *'Oh that's sad. I'm last then. I may not be able to have a go if I'm last. I've got a lesson.'* On this occasion, consideration was given to Pierre's situation and he was able to take his turn before leaving the session to attend the other lesson.

An example of the procedural knowledge developed by students, when they learned to access the LDCR system, was found in a descriptive statement made by John. He described his progress as he accessed the LDCR system saying, *'I'm just trying to find the URL. Here. Here it is. Copy.'* Having copied and pasted the URL from the chat-room into his browser, John added, *'OK, just putting my webcam on. And once I'm up there ... we are starting in three (seconds).'* John then proceeded to count down to the moment when he clicked on the forward button to drive the robot around the robot field saying, *'Five, four, three, two, one ...'*

The development by students of the procedural knowledge associated with maintaining a connection to the LDCR system was identified in a statement made by Joshua, an isolated student living in a rural setting. Joshua described his difficulty maintaining connection to the LDCR system due to intermittent Internet connection during a weather event saying, *'Whenever I put the URL in, it says unable to connect. The reason I'm having so much trouble is because my computer is glitching. I've got the storm right now.'*

Statements made by students also described their knowledge of the procedures they needed to use for learning to log-out of the LDCR system when their turn had ended. For instance, when Oscar was asked, at the end of his turn, if he had logged-out of the LDCR system, he confirmed this saying, *'Yes, I did.'* However, on most occasions, students automatically logged-out of the LDCR system and this type of autonomous behaviour indicated a high level of mastery of the procedures associated with operation of the LDCR system.

The data show students had developed the procedural knowledge needed to operate a robot remotely, as evidenced in descriptive statements about the procedures they had learned to access the LDCR system, maintain a connection and then log-out when finished.

#### **4.4:1(b) Technical skills**

Following the development by students of the procedural knowledge required to enable them to use the LDCR system, students then needed to learn technical skills to enable them to operate the robot remotely using the LDCR system. Specifically, these technical skills

involved the application by students of the procedural knowledge they had developed to the ‘physical’ mastery of the directional control required to manoeuvre the robot around the robot field. Students used their computer mouse or keyboard arrows to select the ‘forward’, ‘right’, ‘left’, ‘reverse’ and ‘stop’ buttons from the webpage, and the button selection required considerable hand-eye coordination.

The development of directional control of the robot was a major part of the technical skilling of students, as demonstrated in numerous video transcripts statements. For example, when Debbie needed assistance in learning to control the robot remotely using the buttons, Max described the procedure to her saying, *‘You just need to hold down the mouse on the right or left button and then it will go or stop turning.’* In another example Tom described what happened when he selected the ‘right’ button, saying, *‘Every time I go right, it goes a little more to the right when I stop it.’* Tom then discussed the over-run by the robot with the technician, with the over-run attributed to latency; that is, the delay that had occurred between Tom’s connection to the LDCR system, the server and the robot. Then, following a modification to the controls, students were able to operate the robot more precisely by holding their mouse button down. Max described the refinement to the controls saying, *‘It’s a lot easier than pressing stop every time, and you’ve got a lot more control (of the robot).’*

As a measure of their ‘physical’ mastery of the directional control of the robot, the average time taken by students (n=14) to manoeuvre the robot around the robot field was recorded through a series of time trials (4) that were conducted towards the end of the study. The average results recorded for fourteen students during the four time trials are shown in Figure 4.

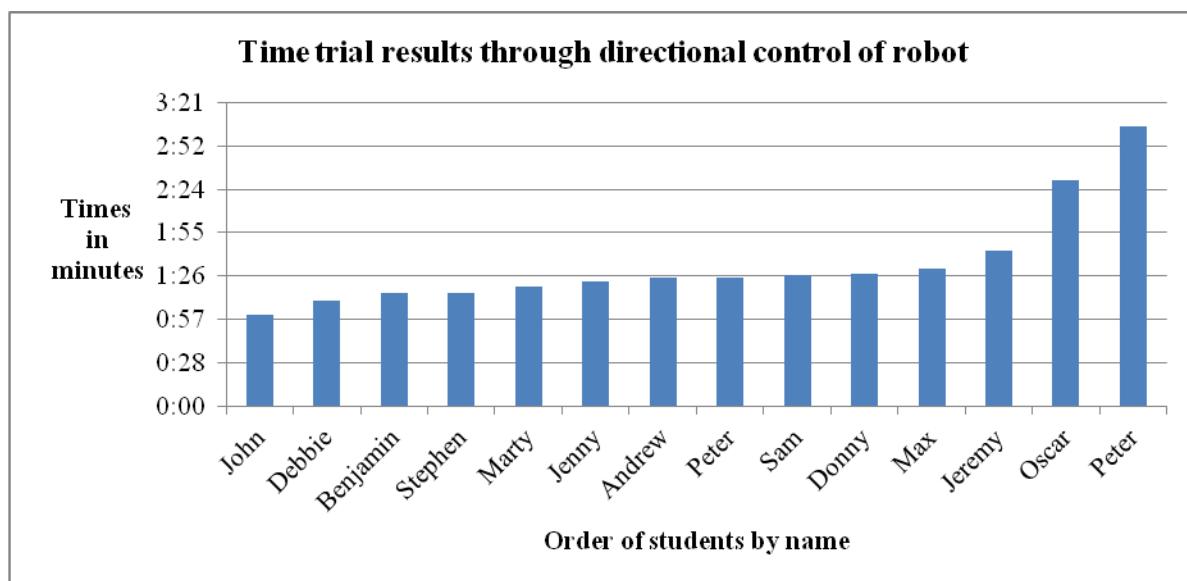


Figure 4: Average robot time trial results recorded by students

The data in Figure 4 showed that, on average, John recorded the fastest times and Peter the slowest. The majority of students took slightly longer to complete the time trial than John, although their times were not significantly slower. It could be concluded, then, that when compared to the other students in the study, John achieved the greatest mastery of the directional control of the robot, and most students achieved a similar level of mastery. However, further research would need to be undertaken to establish any correlation between

the time trial results of individual students and their mastery of the directional control of the robot. What can be concluded from the average times recorded in the four time trials is that most students developed increased mastery of the technical skills needed to successfully operate the robot remotely using the LDCR system.

Within the video transcript data, students also demonstrated greater proficiency in technical skills related to the use of component parts associated with the robot and the LDCR system. These components included the front camera on the robot, its 'eye', and the cameras that were positioned around the robot field. Statements made by students indicated they had learned to 'read' information from the cameras that were placed around the robot field and, as a consequence, were able to use information from the cameras to monitor the position of the robot and measure its speed as the robot was manoeuvred.

As an example, Jeremy identified a problem with the front camera, saying, *'I'm already in, but I can't see the front camera.'* Then when informed by the technician that the camera was reloading, Jeremy replied, *'OK, I shall wait.'* When the technician advised that the camera should now be working, Jeremy commented, *'No, not yet.'* Then when asked what he could see, Jeremy described the function of each camera, saying, *'Well the one on the left side, colours, the one on the right side, it's clear. The one down the middle, near the first front camera, the front camera is still loading.'* Then he added, *'Front camera is on, I repeat, the front camera is on.'* While Jeremy's statement provided evidence of the development of the new technical skills students needed to be able to physically operate the robot remotely using the LDCR system, his statement also highlighted the communication and social skills students needed to learn to enable them to work collaboratively with teachers, classmates and the technician.

Evidence of the development of technical skills, then, was found in numerous statements where students had described 'what' they had done and 'when', as they learned to physically operate the robot remotely using the LDCR system, and through the results of the time trials.

#### **4.4:2 Student explanations of their learning**

In determining the complementary skills learned by students when they operated a robot remotely using a Long Distance Control (LDCR) system, their 'explanatory' statements, as identified in the video transcript data, were examined. The examination included statements where students had used higher-level thinking, or metacognition, to explain their learning about the remote operation of the robot using the LDCR system.

##### **4.4:2(a) Metacognition**

Evidence of higher level thinking, or metacognition, was identified in a statement where Marty explained the changes he had noticed following the modification to the control of the robot. Marty said, *'It's a lot easier because I don't have to time it. I actually know where [the robot] is going to stop because back on the old version it was not very precise.'* Marty demonstrated, in this statement, that he had applied higher level thinking when comparing the remote operation of the robot before and after the controls had been modified, and that he had arrived at a conclusion about these changes, based on his comparison.

More conclusive evidence of the development of metacognition by students was identified in statements where they had explained computer programming, or coding, tasks associated

with the remote operation of the robot using the LDCR system. Peter, for instance, announced during one session, *'I have code to test. I just want to check around the track, just to see what the times are (for the robot).'*' Then, when the robot hit one of the walls on the robot field as he tested his code, Peter exclaimed, *'Damn. It was too early, now too late.'* There followed a discussion between Peter and the technician in relation to adjustments Peter needed to make to his code to fine-tune the times, or run lengths, of the robot on sections of the robot field. Peter modified the code and successfully tested it during a later session.

In another example of metacognition, Peter made suggestions to the technician in relation to programming that would allow students to sound the horn on the robot as they operated it remotely using the LDCR system. Peter explained his suggestions saying, *'I know I'm making a lot of requests but I think using arrow keys from the keyboard might be easier. The arrow key, down, left, right, and enter for the horn.'* Peter's statement convincingly demonstrated that he had applied higher-level thinking; that is metacognition, to the design and solution of problems related to the remote operation of the robot using the LDCR system.

Finally, the development of metacognition by students was clearly evident in statements where they reflected on and explained the relevance of their experience in learning to operate a robot remotely using the LDCR system. Jenny, an isolated student living in North Queensland, explained her experience made extrapolations to what another student might experience saying,

*Well, being online and controlling a robot from a long distance is pretty cool. Because you get to watch the robot move ... further. If you're controlling it from, say if you were in Cairns, and you controlled the robot from there and all the way down in Brisbane it would actually be pretty cool to see it move.*

To summarise, the third research question investigated the learning by students of complementary skills when they operated a robot remotely using a LDCR system, as evidenced in video recordings. Based on transcripts that were created from the video recordings (Abasi & Taylor, 2007), an in-depth examination was undertaken (Knoblauch & Schnettler, 2012) of the descriptions and explanations made by students of their learning when they used a LDCR system to operate a robot remotely. Then the descriptive statements made by students were analysed to determine the procedural knowledge and technical skills developed by students. The data indicated that students had developed the procedural knowledge needed to operate a robot remotely, including the knowledge needed to access the LDCR system, maintain a connection and then log-out when finished. Students had also developed the technical skills required to 'physically' operate the robot remotely using the LDCR system, as demonstrated in the directional control of the robot and use of its component parts, and confirmed in the time trial results.

The explanatory statements of students were also analysed to identify the use of higher-level thinking that is metacognition, to explain their learning about the remote operation of the robot using the LDCR system. The data provided conclusive evidence of the development of metacognition by students as identified in statements where they had explained computer programming, or coding, tasks associated with the remote operation of the robot using the LDCR system, and through modifications they had suggested to the robot that involved coding. Students also demonstrated high-level metacognitive function when they compared and reflected on their experiences when operating the robot remotely using the LDCR system. It can be concluded, therefore, that students developed a quantifiable set of



complementary skills as a result of their remote operation of the robot using the LDCR system.

## Summary

In this chapter, the three research questions were investigated through an analysis of data gathered from surveys, a blog, and video recordings. The data were collected simultaneously during 2014 and consisted of both quantitative (numeric) and qualitative (text) information.

In the first research question, student perception of their learning when they operated a robot was examined using data collected from surveys. Within the surveys, statements were identified as evidence of student motivation (Bandura, 1986), including the development of cognitive and social presence (Jimoyiannis & Angelaina, 2012) and self-efficacy in an online setting (Zhan & Mei, 2013), along with the learning strategies used by students (Pintrich, 2002). The data revealed that the majority of students demonstrated high levels of motivation and enhanced self-efficacy and these were directly attributed to participation in online and blended learning sessions about robots. The data, then, confirmed that following their operation of a robot, the students had developed greater proficiency in their use of metacognitive strategies, particularly in their use of strategic knowledge, knowledge about cognitive tasks, and self-knowledge in relation to robots.

For the second research question, the STEM skills learned by students through robots were identified in data gathered from a blog. The blog data was analysed to identify evidence of the development by students of social and cognitive presence (Jimoyiannis & Angelaina, 2012) and their ability to engage in reflective reasoning about robots, as evidence of STEM learning (Australian Government, 2014c), in which science, technology, engineering and mathematics was integrated (Kaufman et al., 2003). As evidence of STEM learning, statements were identified within the blog data where students had made reference to robot adaptations and robot operation, in addition to student-to-student communications that indicated STEM thinking. The data showed that the majority of students who responded through their blog rather than in the study, had identified, applied and integrated concepts from STEM, and that they had used STEM concepts to understand and solve complex problems about robots (Balka, 2011). They had engaged in STEM learning that included creativity, problem solving, critical thinking and communication skills, and their engagement matched the criterion for STEM learning that has been articulated by the Australian Government (2014c).

For the third research question, the complementary skills learned by students when they operated a robot remotely using a LDCR system, were identified using data from video recording transcripts. The transcripts were analysed (Abasi & Taylor, 2007), through an in-depth examination (Knoblauch & Schnettler, 2012), of statements where students described and explained their learning of complementary skills in relation to the remote operation of the robot using the LCR system. The data indicated students had developed the procedural knowledge needed to operate a robot remotely, as evidenced in statements where they had described the procedures they had learned to access the LDCR system, maintain a connection and then log-out when finished. They had also developed the technical skills needed to 'physically' operate the robot remotely using the LDCR system, as confirmed in time trial results. Within the data, evidence was also found of the development of metacognition by students as demonstrated in their explanations of computer programming, or coding, and modifications they had suggested for the robot that also involved coding. Further evidence of

the metacognitive function of students was revealed in the comparisons and reflections they made in relation to their experiences of remote operation of the robot using the LDCR system.

In summary, the interrogation of the data confirmed the evidentiary basis for the findings of the study in relation to student perception of their learning, and the STEM skills and complementary skills developed by students, when they learn to operate a robot remotely using a LDCR system. Through the investigation of the research questions, the data revealed distinct patterns in the learning of students following their remote operation of a robot using a LDCR system. Based on the patterns identified in student learning, conclusions have been drawn across the research questions and these will be discussed in the next chapter.

## **Chapter 5**

### **Discussion**

#### **5.1 Introduction**

In this study, an investigation was undertaken of the skilling of Australian students in digital technologies through the use of educational robots. The study was based on three research questions:

1. When students operate a robot, what are their perceptions of their learning?
2. What Science, Technology, Engineering and Mathematics (STEM) skills do students learn through robots?
3. What complementary skills do students learn when they operate a robot remotely using a Long Distance Control Robot (LDCR) system?

The research model adopted for this investigation was based on case study design (Creswell et al., 2007). Using a combination of quantitative and qualitative methodologies (Babbie, 2014), research data was gathered from surveys, a blog, and video recordings to determine student learning following their remote operation of a robot using a LDCR system. Thus, a database was created that consisted of both quantitative (numeric) and qualitative (text) information. The sample population in the study was drawn from a group of 32 (n=32) primary students, both male and female, who were aged 9-12 years and enrolled at Brisbane School of Distance Education (BSDE), during 2014. Students lived in a range of rural and remote and metropolitan settings throughout Queensland. They used the LDCR system over the Internet to operate the robot that was located in Brisbane. The students were selected for this study as they had demonstrated an interest in robots through their voluntary participation in the BSDE Robots Project 2014. Data sets were created following an analysis of the information in the surveys, the blog and the video recordings. Tentative findings that were based on the initial interpretation of the data were reported in the previous chapter.

#### **5.2 Analysis of results**

In this chapter, the interpretative basis of the study has been deepened through an analysis of the findings, using a process of ‘triangulation’, to determine whether convergence was established within the data (Creswell, 2003). Triangulation is defined here as the combination of methodologies in the study of the same phenomenon (Denzin, 1978). Following the triangulation of the data, conclusions were drawn that provided more definitive answers to the three research questions. It was anticipated these conclusions would provide results that either verified or refuted the knowledge claims made in the literature around the skilling of students in digital technologies through the remote operation of a robot using a LDCR system. The three data sets, that is, the surveys, the blog and the video recordings, were triangulated to provide answers to the research questions that were posed in this study.

##### **5.2(a) How students perceived their learning about robots**

In the first research question, the initial findings from the survey data indicated student perception of their learning was enhanced when they operated a robot, as evidenced in high levels of motivation and higher self-efficacy (Bandura, 1986, 1994, 1997). Gains in confidence, as indicated in the survey data, were a direct consequence of the actions taken by

students when learning to operate a robot and resulted in students reaching their goal, that is, the operation of a robot (Hemmings & Kay, 2009). The enhanced self-efficacy developed by students had impacted positively on the effort invested by individual students when learning to operate a robot, as measured in their achievements (Moriarty, 2014). To determine points of convergence between the first research question and the second and third questions, the data from the blog and video recording transcripts were interrogated.

Within the blog data, evidence of student perception of learning that could be attributed to their operation of a robot was identified in the communication between students and this evidence was correlated with the development of their social and cognitive presence (Jimoyiannis & Angelaina, 2012). While the blog data revealed that over half of the student-to-student communications (58%) were 'routine' or 'social' in nature, there was strong evidence within these communications of the development by students of highly positive attitudes, beliefs, self-esteem, self-confidence, and motivation. Students had made emphatic statements in the blog where they had described their experiences with the robot as '*absolute fun*' and declared that '*the Robots Project was by far my favourite subject*' in Year 6. The survey findings, then, of enhanced perception by students of their learning are verified by the blog. Further research would need to be undertaken to determine any correlation between physical location, social presence and blog usage.

The examination of the video recording transcript data revealed that enhanced student perception correlated directly with the development of complementary skills required to operate a robot remotely. When students developed the procedural knowledge and technical skills that were required to operate a robot remotely using a LDCR system, they enjoyed successes that were shared with fellow participants and these were manifested in enhanced self-efficacy. It can be concluded, therefore, that reasonable certainty has been established between the data in relation to enhanced perception of learning by students when they operate a robot, as evidenced in higher levels of metacognitive function.

### **5.2(b) STEM skills learned by students through robots**

In the second research question, the findings from the blog data showed initially the majority of students had learned STEM skills that included creativity, problem solving, critical thinking and communication in accordance with government expectations (Australian Government, 2014b). Students had identified, applied and integrated concepts from STEM and used these concepts to understand and solve complex problems involving robots in a similar way to those studied by Balka (2011). It was found students had used the blog to externalise their reflective reasoning about their STEM learning through robots (Zeng & Harris, 2005), and had offered evidence, elaboration, and justification through critical evaluations of the solutions they had proposed and shared with each other (Loving et al., 2007). The blog data had also provided strong evidence of the viewing by students of their thought progression over time (Ellison & Wu, 2008), and the growth of their individual knowledge base (Baggetun & Wasson, 2006). To determine convergence between the second research question and the first and third questions, the survey and video transcript data was examined for evidence of STEM skill learning by students.

The survey data indicated that, at the start of the study, the majority of students (70%) had no prior experience of robots. In addition, 72% (n=13) stated they wanted to learn how to build, program and control robots, and 44% of students (n=8) wanted to learn how robots work and their uses. Evidence was also found within the survey data, of the development by students of

strategic knowledge and knowledge about cognitive tasks (Pintrich, 2002), that was related specifically to robots and aligned directly with STEM skills. By the end of the study, students could describe their STEM skill acquisition, as evidenced in enhanced self-knowledge.

Within the video recording transcript data, STEM skills were correlated with the procedural knowledge and technical skills developed by students to operate the robot remotely using the LDCR system. Evidence was also found in the transcripts of the metacognitive strategies that students had applied when developing their procedural knowledge and technical skills. Notably, none (0%) of the students in the study had operated a robot remotely using a LDCR system at the start of the study. By the end of the study, students had not only demonstrated their mastery of the procedures and technical skills needed for remote operation of a robot using a LDCR system, they had also demonstrated enhanced STEM skill learning. It is concluded, therefore, the evidence supports the findings around the learning of STEM skills by students through robots, such as computer coding skills.

### **5.2(c) Complementary skills learned by students through remote operation of a robot**

In the third research question, initial findings from the video recording transcript data (Abasi & Taylor, 2007), confirmed that students had learned a range of complementary skills when they operated a robot remotely using the LDCR system. Along with the development of knowledge and skills that was related to the operation of an advanced robotic system using a remote learning interface (Goldstain et al., 2011) students had also demonstrated their understanding of the robotic behaviours of the Lego NXT robot (Kulich et al., 2013) for design purposes. Strong evidence was found in the transcripts of high level metacognitive function by students when they learned the complementary skills associated with the remote operation of the robot. In determining convergence between the third research question and the first and second questions, the survey and blog data was interrogated.

Within the survey data, the learning strategies used by students were correlated with their development of specific complementary skills. Their strategic knowledge and knowledge of cognitive tasks was matched with the development by students of the procedural knowledge and technical skills needed to successfully operate the robot remotely using a LDCR system. Complementary skill development was also associated with STEM thinking and metacognition, as evidenced in the blog data. Students had designed problems and proposed solutions that were directly related to the robot and the LDCR system that included a test, for instance, of the weight-bearing capability of the robot, and measurements of the latency (or delay) in the LDCR system.

The blog data indicated students had shared information on how to build and operate robots and had also discussed tertiary study and careers in robotics. Then, within the transcript data, the computer programming, or coding, skills that students had developed provided irrefutable confirmation of complementary skill development as evidenced in the strengthening of their metacognitive capabilities. The data, it can be concluded, has verified the development by students of complementary skills, specifically higher levels of metacognition, following their remote operation of a robot using a LDCR system.

In summary, it is claimed that the key findings for the three research questions posed in this study have been confirmed. This was achieved through the consensus that has been established between the data, and has resulted in the deepening of the interpretative basis for the study. Based on these findings, conclusions have been drawn, and are these are used to

situate the study within what is currently known about educational robots and the STEM learning of primary students. Prior to the discussion of the findings, however, the limitations to the research that was conducted in this study will be made known.

### **5.3 Limitations to the study**

The research conducted in this study was impeded somewhat due to limitations that were associated with methodological, pedagogical and technical issues. First, the discussion will focus on the restrictions that were a consequence of the survey design in terms of their impact on the research methodology. Then, pedagogical and technical issues, although inextricably linked due to the centrality of educational technology to the study, will be discussed separately to exact the restrictions each imposed on the research.

#### **5.3(a) Methodological issues**

The main limitation to the methodology was the fact that the study was a trial that was conducted once and at only one Queensland school. The study needs to be replicated at other schools of distance education in Queensland and at other sites throughout Australia to verify findings. Another limitation to the methodology was the surveys. It is common practice in studies such as this, where a case study approach is applied, to use a pre-test and post-test (Babbie, 2014). The surveys that were administered at the start and end of the study were intended to serve this purpose; however, retrieval of completed surveys was difficult due to the fluidity of the student population at BSDE that resulted in a low response rate for the second survey. Also, the logistics associated with the operation of the LDCR system placed extra-ordinary demands on the researcher. As a consequence, the design of the surveys was compromised, resulting in a limited range of questions and an over-reliance on information gathered from short-answer and multiple-choice questions. In hindsight, the inclusion of a Likert scale, with seriated facial representations that corresponded to emotional states, would have been easier to administer, and may have provided more quantifiable data.

#### **5.3(b) Pedagogical issues**

Three issues that related directly to pedagogy have been identified as impediments to the research undertaken in this study. All three issues were a consequence of the fact that the LDCR system is an emerging digital technology (Minamide et al., 2008, 2009) had not been tested in an Australian school prior to this study.

First, given that the remote control of a robot using a LDCR system had not previously been attempted in Queensland, the paucity of evidence on the remote control of robots (Kulich et al., 2013), meant there was limited information available that could be used to justify the introduction of a LDCR system as a new pedagogical approach. The ‘novelty’ of the LDCR system, then, restricted the research undertaken in this study because of the total reliance that was placed on local support and resourcing at school level. In effect, the impetus behind the use of the LDCR system at BSDE came from one person, the researcher, and this type of arrangement, with its reliance on one person, would be unsustainable long-term.

Second, compounding the lack of evidence on the use of a LDCR system, the delay by the Education Council in the endorsement of the new *Australian Curriculum: Technologies - Digital Technologies* (ACARA, 2015b), further delayed the implementation of the *Digital Technologies* curriculum (ACARA, 2015b). Consequently, the study could not be framed

within the new *Digital Technologies* curriculum (ACARA, 2015b) but was instead conducted as a trial, tantamount to a ‘hobby club’ for students that was managed in addition to regular school activities at BSDE.

Third, the research for the study was also restricted due to the voluntary nature of student participation. The students (n=32) lived in dispersed geographical locations and were voluntary participants in the BSDE Robots Project 2014. Due to the fluidity of enrolment at BSDE and the transition of many of the Year 6 students to high school, some participants at the start of the study were no longer enrolled at BSDE when data was gathered at the end of the study. Data collection opportunities, therefore, were determined by student availability.

### **5.3(c) Technical issues**

Two technical issues that imposed operative restrictions on the research were related directly to the use of the LDCR system at BSDE.

First and foremost, technical infrastructure problems posed a serious impediment to the use of the LDCR system in the early stages of the study. This problem occurred because access to the Education Queensland (EQ) learning management system was blocked by security firewalls. To overcome this problem, the LDCR system was operated externally to EQ using a private Internet connection, and the robot and the robot field were also housed off-campus.

Second, the lack of specialist technical knowledge at BSDE in relation to robotics and the LDCR system meant expertise had to be sourced elsewhere. The voluntary services of a graduate Mechatronics Engineer were procured, and this skill set was found to be essential in the operation of the LDCR system and in the resolution of technical challenges encountered during the study.

### **5.4 Discussion**

The findings from this study are situated within the context of what is currently known about the use of educational robots and the STEM learning of primary students, in particular metacognitive strategies used, such as strategic knowledge, knowledge about cognitive tasks, and self-knowledge (Pintrich, 2002), when they learn using a robot. These findings are then discussed in terms of their implications for the skilling of Australian students in digital technologies.

Internationally, the use of educational robots has been heralded as the transformational ‘all-in-one technological learning tool’ for STEM teaching and learning in K-12 education (Eguchi, 2014b; Barreto & Benitti, 2012; Barak & Zadok, 2009), and worldwide government policy makers have placed renewed emphasis on the use of robots as instructional tools for the teaching of STEM. In the United Kingdom (UK), for instance, the teaching of computer coding and engineering design has become a major focus in school curricula (Department for Education, the U.K., 2013), while in the United States of America (USA), the government has strongly promoted STEM learning (Eguchi, 2014a) and urged American students to immerse themselves in robotics (STEM Center USA, 2014). The growing international momentum that has built around robotics is hardly surprising given that robotics is widely referred to as the ‘mother’ of all subjects and the most forward-looking discipline of our time (STEM Center USA, 2014).

In Australia, however, the momentum around robotics and STEM has been slower to build. According to Australia's former Chief Scientist, Professor Ian Chubb, Australia is currently locked into a cycle of disengagement around STEM that is failing its teachers and students and placing business at risk into the future (Australian Government, 2014c). To redress this situation, Chubb urged Australian education to focus on the preparation of a skilled and dynamic STEM workforce that ensures young Australians can live and work in an increasingly competitive global marketplace. Closer to home, the skilling of Australians in STEM is imperative in terms of the national interest in what is termed the Asian century (Australian Government, 2012).

In research published by Deloitte Access Economics (2015), an urgent need was identified for the training of an Australian workforce equipped with the ICT skills to fuel an increasingly digitally driven economy (Australian Computer Society, 2015). The report, *Australia's Digital Pulse* (Deloitte Access Economics, 2015), predicts the demand for ICT workers in Australia will increase by 100,000 workers over six years, from around 600,000 workers in 2014 to more than 700,000 workers in 2020. Clearly, the skilling of an additional 100,000 ICT workers by 2020 poses a serious challenge for Australian policy makers. In meeting this challenge, the report recommends the inclusion of computing skills and technical ICT capabilities in the Australian curriculum, beginning at the primary school level. Australian educators, then, have a critical part to play in the skilling of young Australians in ICT if the looming skills shortage is to be averted (Australian Computer Society, 2015).

A continuing hindrance to the skilling of Australian students in ICT, however, has been the delayed implementation of the new *Digital Technologies* curriculum (ACARA, 2015b). Since undertaking this research, the national priorities of the Australian Government have changed, and the change of priorities has seen acceleration in the development and implementation of the Technologies component of the Australian Curriculum at national and state levels (Australian Computer Society, 2015). According to the former Federal Communications Minister and Prime Minister at the time of writing, The Honourable Malcolm Turnbull MP, what is needed in Australia is an "innovation insurgency" that would see school children as young as five or six learning computer coding alongside mathematics, science and English (Australian Resellers Network, 2015). It can be concluded, then, that the Australian Government supports the innovative teaching of STEM in Australia.

In this study, the trial of an innovative approach to STEM teaching was undertaken using a LDCR system, in conjunction with educational robots. The aim of the research was to determine the impact of a LDCR system on the skilling of Australian students in digital technologies. Unequivocally, the results revealed that when students learned to operate a robot remotely their perception of their learning was enhanced, their STEM learning increased, and they developed a range of complementary skills. Enhanced perception of learning meant students were highly motivated to learn STEM skills through robots, and they developed STEM specific skills such as quantification, critical thinking, and creativity, in parallel with STEM disciplinary knowledge. Students developed complementary skills, as measured in higher levels of metacognitive capability, through their mastery of the procedural knowledge and technical skills required for remote operation of a robot using a LDCR system.

The results of this research study, then, have provided cogent evidence that the skilling of Australian students in digital technologies can be escalated when a LDCR system is used in conjunction with educational robots. The finding that the skilling of Australian students in



digital technologies can be escalated when a LDCR system is used in conjunction with educational robots comes at a time when Australian schools are struggling to provide instruction in robotics due to the lack of access to robots experienced by students in many parts of Australia. The infamous ‘tyranny of distance’, together with the prohibitive costs associated with sending a physical robotic device to each student or with having students travel to centres where they can interact with robots, continue to impede the teaching of robotics and STEM in Australia.

In terms of access and equity, this study recommends that the LDCR system be made available to all Australian students as a strategy to help them learn STEM through the use of robots, as required in the new *Digital Technologies* curriculum (ACARA, 2015b). At June 2013, Australia had 4.37 million children under the age of 15 years, accounting for 19% of the total population (Australian Bureau of Statistics, 2013). Potentially, over 4 million young Australians can be the direct beneficiaries of the findings from this study. Within these numbers, there are some 379,779 primary students in Queensland (Queensland Government, 2011), to whom the LDCR system could be made available, as a logical extension of the initial trial undertaken at BSDE. The provision of a dedicated space at BSDE for a robot field or a classroom or computer lab reserved solely for robotics could see larger numbers of on-site students working collaboratively with students off-site using a blended learning model, as demonstrated in this study.

Used in conjunction with the LDCR system, the blended learning model could also be extended to rural and remote communities in Australia as a ‘close the gap’ strategy to increase student engagement and lift school attendance rates. Used in this way in rural and remote settings, the LDCR system may help fulfil the expectation of the Australian Government that education will be a key driver in improving outcomes for Aboriginal and Torres Strait Islander peoples (Australian Government, 2015). Overtures could also be made to the organisers of robotics competitions, such as the First Lego League Australia Competition, to allow teams to compete from off-site using the LDCR system, and these teams could include students in rural and remote communities.

Building on the blended learning model used in the trial at BSDE, it is envisioned that the use of the LDCR system could be ‘scaled-up’ to allow multiple groups of students to operate robots remotely and simultaneously. Hypothetically, in a group consisting of twenty-five students with each student using one robot, twenty-five robots would be required at any given time. During a regular five-hour school day, the allocation of thirty minutes per student for LDCR system usage would mean that 250 students per day, and 1,250 students per week, could learn to operate a robot remotely using a LDCR system. Based on a school year of forty weeks with twenty-five students using twenty-five robots, 50,000 students per year in Australia would gain access to robotics education.

According to the President of the Australasian Association of Distance Education Schools (AADES), Mr M. Kent (personal communication, October 22, 2015), there are approximately 30,000 students currently enrolled in schools of distance education in Australia, compared to the approximately 3,694,101 students enrolled in Australian mainstream schools (Australian Bureau of Statistics, 2015). To provide access to robots for students in schools of distance education, it is calculated that twenty-five Lego EV3 robots would cost approximately \$12,500. Extra costs would be associated with the purchase of software licences, staffing and charges for Internet usage.

An LDCR hub holding 25 robots could provide twenty-five school hours of class engagement per week, or 1000 class-hours per 40-week school year. Assuming robotics forms 25% of the 64 hours design time for Digital Technologies students in Year 5-6, this is sufficient to support learning for 62 classes. The cost would be less than \$10 per student. Assuming distance education students are distributed evenly by age, and that robotics was only used in Years 3-6, seven hubs would be needed at a total cost of \$81,000. This modest investment would provide a critical learning resource right around Australia for a very modest investment. On a larger scale, access to the LDCR system could be broadened through the use of an online booking system to allow 24/7 operation of robots, and this booking system could open opportunities for sales to the international education market. Consideration could also be given to the extension of the usage of the LDCR system to students and teachers in developing nations, as part of Australia's aid program in the Australasian-Pacific region.

It can be concluded, therefore, that the most important contribution made by this study is that Australian students can learn to operate a robot and become skilled in digital technologies through the use of a LDCR system, and this learning and skilling is irrespective of their physical location. The study has built on the proud tradition of distance education in Australia and thus forms part of the continuing story of innovative technological solutions overcoming the 'tyranny of distance'. Rather than being a tyrant or barrier, this work has confirmed that distance provides unlimited opportunity because it opens new frontiers for technological innovation that can be of benefit to all Australian students and to our nation. However, access to educational robotics presents seemingly insurmountable challenges for students in many parts of Australia due to geographical location and the costs associated with providing physical robots. This study puts the case for the wider use of the LDCR system in Australian schools to enable greater numbers of Australian students to operate robots and develop STEM learning. Used in this way, the LDCR system may help address problems identified in the literature that point to greater involvement in robotics education to ensure Australian students can compete in the 21<sup>st</sup> century global economy (Australian Government, 2014b; ACARA, 2015a).

Furthermore, the fact that Australia is now the only country in the OECD to not have a current national strategy that bears on science and/or technology and/or innovation was identified by Australia's former Chief Scientist as a major impediment to the building of a stronger more competitive Australian economy (Office of the Chief Scientist, 2014). Clearly, innovative solutions are required if Australia is to train an extra 100,000 ICT workers by 2020 and build the STEM skilled workforce needed to power the digitally-driven Australian economy that is envisioned for the future (Deloitte Access Economics, 2015). The recommendations that have emerged from the findings in this study, along with implications for future research will now be discussed.

## **5.5 Recommendations**

The main recommendation to emerge from this study is for consideration to be given to wider use of the LDCR system as a strategy to enhance the teaching of robotics and the learning of STEM in Australian educational settings. The results of this study have demonstrated that the LDCR system enabled Australian primary school students to learn to operate a robot remotely and develop STEM skills, irrespective of their physical location. In the trial of the LDCR system conducted at BSDE in 2014, reasonable certainty has been established between the data in relation to enhanced perception of learning by students (Bandura, 1986, 1994, 1997; Hemmings & Kay, 2009; Moriarty, 2014; Jimoyiannis & Angelaina, 2012) when they operate

a robot, as evidenced in higher levels of metacognitive function (Pintrich, 2002). As a ‘one-to-many’, cost efficient digital solution that overcomes the ‘tyranny of distance’, the LDCR system has the potential to upscale and expedite the teaching of STEM in Australia and boost the learning of STEM by Australian students.

Following the recent endorsement of the new *Digital Technologies* curriculum (ACARA, 2015b) in September 2015, the teaching of STEM and robotics in all Australian schools is no longer optional, and this mandate strengthens the case for the use of the LDCR system. In an announcement made in 2015 by the Queensland Premier, Annastacia Palaszczuk, every state school will offer the Digital Technologies curriculum from 2016 and robotics and computer coding will be taught to all Queensland students from prep to Year 10 (Queensland Government, 2015). Given the recent endorsement of the new *Digital Technologies* curriculum (ACARA, 2015b), the opportunity now exists in Queensland schools for the LDCR system to extend and accelerate the teaching of robotics and computer coding, particularly for rural, remote and isolated students, and in a cost-effective manner. The wider use of the LDCR system, therefore, is justified and worthy of support at Federal and State level. Estimates of forward costing indicate the wider use of the LDCR system in Australia would be financially viable, it begs the question: how expensive would it be for Australia to not take up this opportunity?

Second, given that the initial trial of the LDCR system was undertaken at BSDE (Hastie et al., 2013), and following the high level of success reported in this study, an opportunity is now presented for BSDE to play a lead role in extending the use of the LDCR system through collaborative partnerships with other Schools of Distance Education in Australia, and more widely into mainstream education. Such an initiative may go some way towards redressing serious concerns about the skilling of more Australia’s students in STEM if the nation is to meet the demands of a changing labour market and stay competitive in the global economy and in our region (Australian Computer Society, 2015; Australian Government, 2014b; Office of the Chief Scientist, 2014; Marginson et al., 2013; OECD, 2013; Thomson et al., 2013; ABC News, 2013; Australian Government, 2012).

Third, it is recommended stronger support be given to Australian educators working at the cutting-edge of innovation in digital technologies. As described in this study, innovation frequently involves risk and depends on risk-takers, yet the over-reliance on enthusiastic individuals, however committed, is not sustainable in the long-term. Extra resources must be dedicated (Australian Government, 2014b; Office of the Chief Scientist, 2014) and the extra allocation of resources could include adjustments to workloads and the provision of extra technical infrastructure. What is clear, however, is that Australia’s innovative educators require much higher levels of support and this support needs to be provided more willingly and in a timely manner.

Fourth, it is recommended Education Queensland establish protocols to facilitate closer cooperation between IT system managers and educational innovators when new digital technologies are introduced. Protocols of this type may have mitigated the disruption that was associated with the LDCR system, as reported in this study caused by an Education Queensland firewall that could only be resolved through the relocation of the LDCR system offsite. Given the challenges confronting Australia in building its future STEM workforce (Australian Computer Society, 2015; Deloitte Access Economics, 2015; Australian Government, 2014b; Office of the Chief Scientist, 2014), technical issues of the sort described here cannot be allowed to stymie the use of innovative digital technologies such as

the LDCR system.

Fifth, the continuation of the collaboration between BSDE, an Australian school of distance education, and the Kanazawa Technical College (KTC), a Japanese university, is highly recommended. The trial of the remote operation of a robot using a LDCR system, as reported in the Literature Review in Chapter 2, came about through an international partnership between BSDE and KTC (Minamide et al., 2008, 2009, 2012; Hastie et al., 2013). The donation of the LDCR system to BSDE by KTC is acknowledged as pivotal to the success of this study. In what is termed the Asian Century (Australian Government, 2012), Australian educators are urged to seek collaborative research and development opportunities with partners in this region to promote the development of STEM learning and robotics.

## 5.6 Conclusion

In this study, an investigation of the skilling of students in digital technologies was undertaken at an Australian school of distance education using an emerging digital technology, a Long Distance Control Robot (LDCR) system. Primary students aged 9-12 years (n=32) at Brisbane School of Distance Education (BSDE) in Queensland, Australia, participated in a trial of the LDCR during 2014. The students lived in a range of rural and remote and metropolitan settings throughout Queensland. They used the LDCR system over the Internet to operate the robot that was located in Brisbane.

The research established that when primary students learned to operate a robot remotely using a LDCR system, their perception of their learning was enhanced, their Science, Technology, Engineering and Mathematics (STEM) learning increased, and they developed a range of complementary skills, including heightened metacognitive capability. It is attested that the findings of this study are timely given that Australia will face a shortfall of 100,000 skilled ICT workers by 2020 (Australian Computer Society, 2015).

Clearly, the teaching of STEM in Australian schools is an imperative if Australian students are to develop the STEM competencies needed to adapt to a changing labour market and stay competitive in an increasingly digitally-driven global economy (Australian Government, 2014b). In short, the prioritisation of STEM learning, in primary school and the early years of learning, is in the national interest (Office of the Chief Scientist, 2014). With the recent endorsement of the new *Australian Curriculum: Technologies - Digital Technologies* (ACARA, 2015b), which encourages teachers to use robots to teach STEM, the LDCR system offers a way forward. The overcoming of the methodological, pedagogical and technical challenges associated with the use of the LDCR system is very much the story of the success that underpins this study, and another chapter in Australia's story of overcoming the 'tyranny of distance'.

Finally, this study puts the case for the wider use of the LDCR system in Australian schools to enable greater numbers of Australian students to operate robots and develop STEM learning. As a 'one-to-many', cost efficient digital solution, the LDCR system can be used to upscale and expedite the teaching of STEM in Australia, and overcome the perennial challenges posed by the 'tyranny of distance'. At a time when robots are becoming all pervasive, and with scant evidence in the literature on the use of remote robots (Kulich et al., 2013), it is anticipated that the findings from this study will fill a gap in the research on the skilling of primary students in digital technologies using long-distance controlled robots over the Internet, and make a valuable contribution to current academic discussion.

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Appendix A

Student survey 1

**BSDE ROBOTS PROJECT 2014**

August 2014

**Question 1:**

I've had previous experience with robots.

**YES**

**NO**

If YES, what type of robot?

--

**Question 2:**

What would you like to learn about robots?

--

**Question 3:**

What would you like the robot to do?

--



**Question 4:**

**What type of terrain would you like to design for the robot to traverse?**

**Question 5:**

**Would you like to meet guest speakers who are experts on robots? YES NO**

**Question 6:**

**How often would you like our group to meet for the Robots Project?  
Please circle one answer below:**

- Once every week
- Once every fortnight
- Once every month
- Once each school term

**Question 7:**

**Where would you prefer to meet?  
Please circle one answer below:**

- Always on-site at BSDE
- Always virtually via Collaborate
- A mix of on-site (at BSDE) and virtual (Collaborate) meetings

**THANK YOU FOR COMPLETING THIS SURVEY.**

## Appendix B

### Student survey 2

# BSDE ROBOTS PROJECT 2014

## December 2014

NAME: \_\_\_\_\_

### Question 1:

**Please describe what membership of the BSDE Robots Project 2014 means to you.**

[illegible]

### Question 2:

**I've operated the Lego NXT robot DCR14.** **YES** **NO**

**If YES, please describe your experience operating DCR14.**

### Question 3:

What do you know about DCR14?  
Please label the parts of DCR14.



### Question 4:

What did you learn about DCR14 as it moved around the robot field?  
For example: forward, right, left.

### Question 5:

What else would you like DCR14 to do?

### **Question 6:**

**Please reflect on what you have learned about robotics since joining the Robots Project.**

**This can include:**

- **Your on-site visits to BSDE to operate DCR14**
- **Your long-distance control of DCR14**
- **The information that we've shared about robots in our weekly online meetings**
- **Other research that you've undertaken on robots.**

**Any other comments or suggestions?**

**YES NO**

--

**THANK YOU FOR COMPLETING THIS SURVEY.**

## Appendix C

### Video recording transcript sample

TIME	NOTES
00:03	Megan: Good morning, everyone, welcome to the BSDE Robots Project 2014 online meeting (28 November 2014).
00:21	Megan: Our Technician is ready with the Robot Field, ready to go. Today, more robot fun. How much more fun can we have with a robot? We're going to drive DCR14 remotely around the Robot Field.
00:54	Megan: Did you enjoy the Guest Speaker event on Wednesday with Greg Dennis (Scenic Rim Robotic Dairy)? Can you rate it out of 10 please? Some very high ratings, off the scale, that's wonderful. Can you tell me what you liked best? Marty commented (in the chat-room) that he liked the robots that Greg uses to milk his cows. Another student (in chat-room): Amazing milking robots. Megan: I liked the fact that the cows can self-regulate their milking when their udders are full.
01:59	Jenny commented (in chat-room) that she had viewed YouTube video on Greg Dennis. Megan: Jenny, how was it? Jenny: It was very interesting. Mr Greg Dennis he talked about the robot and how it milks the cows, Megan: Was there extra information that you would recommend to us, Jenny? Jenny: Yes, I would recommend it. Jenny shares URL in chat-room.
03:05	Megan: reviewed factual information shared by Greg Dennis during his presentation (processing of milk).
03:58	Megan: Technician, are you right to get underway? Technician: Yes, right to go.
04:13	Megan: Marty are you right to go? Marty, over to you. Megan: We'll start at base. You are welcome to go anticlockwise, Marty, if you wish, see if you can see Greg at the end of the Robot Field, see if you can see Greg's cow.
05:01	Megan: describes dairy theme on robot field, pics of Greg with his prize cow Dyna will be at the top left hand corner, then cows along the far wall, then the mother and calf, need to dodge a cow 'pat' at the bottom. Megan: A lot of fun? This will be fun!
05:56	Megan: Marty, we're ready for you to start. Want us to time you, Marty? Marty: No thanks.
06:14	Megan: OK, Marty over to you. Yes, Oscar, a very cute baby. Technician, Marty's found the horn button! Marty do you want to give it a toot? Toot the horn! Megan: Technician, can you hear the horn? (Technician confirms he can hear the horn.)
06:35	Megan: Hi John. (Welcome John and update him on session.)
06:52	Marty: Something is wrong with it because I can't move it forward, then backwards a small amount, he can't move DCR14, Technician: Remember you need to hold the mouse button down and then stop to let go (Marty had missed a couple of sessions while out at sea on yacht so possibly unaware of horn modification)
07:24	Welcome Max who apologises for being late, Megan: Don't worry as Robots Project is purely voluntary and I know you are juggling lots of other school work
07:47	Megan: Marty can you see the mother and baby? Marty: Yes Megan: Is it a good view? Marty: Yes (in chat-room) Megan: Marty you've done very well. This is brilliant. Marty is logging-on from the galley of his yacht to drive a robot remotely around the Robot Field and round up some cows, and he missed the cow pat! Well done. Well done, Marty. You missed the cow pat! And DCR14 will be most grateful that it doesn't have to go and get its wheels washed off. Well done, Marty. Everyone, give Marty a big clap. Greatly driving, Marty. And it was a pretty quick lap Technician is saying. Technician comments in chat-room on quick lap. Fast work, Marty.
08:55	Megan: Marty, how does it feel to drive the robot with the mouse?
09:15	Marty: It's a lot easier because I don't have to time it. I actually know where it's going to stop because back on the old version it was not very precise. Megan: Thanks, Marty. This is really valuable research data. Thank you, you're all helping me with this research.
10:14	Megan: Donny is reminding us (in chat-room), Technician, about the arrow keys for the controls. Technician: I'll get around to it eventually. Megan: Yes, it's some programming you need to do? Technician: Yes, it's not too difficult.
10:38	Megan: Donny, are you ready to drive? OK, off you go whenever you're ready. See if you can see some cows, Donny. Donny: One of the cameras is not working, 3 <sup>rd</sup> one, the bottom one. Technician: Front camera is working for me. You may want to refresh your webpage. Megan: Do you want to refresh, Donny? Donny: OK. They're working now. Megan: Donny, (you're) doing very well, you've got great control. Jenny, I think he's going to be rivalling you for precision driving. Donny that is expert driving! And he just adjusted to miss the cow pat, just in time. That was close! Well done. Now he's showing off, doing 'donuts'.
12:25	Megan: Yes, Max, we had lots of people here for the session on Wednesday (during Guest Speaker event with Greg Dennis). You were all so beautifully behaved and I'm very proud of your behaviour. You were very fine ambassadors for

	our school.
12:38	<p>Megan: Donny has a comment there (in chat-room), says it looks a bit slower,  Technician: Could be something with our speed.  Megan: It could be our Internet connection at home because of the storm last night, and as you know there was a lot of tree damage, it may have interfered with our connection at home, but it's all working now. I checked with Technician earlier, and we're up and going now. Peter, you're lucky your car windows weren't smashed.  Peter: Our car was just about the only one without a smashed window (hail damage to other cars)  Megan: Peter that is really fortunate for you. I'm so glad you escaped. It can interfere with our Internet connection.  Donny: reports (in chat-room) storm passed on them on Gold Coast</p>
12:49	<p>Megan: Jenny, anything happening? Technician, does it need a reboot?  Technician: No, it's fine.  Megan: Jenny, want to try? There you go, she's off!</p>
14:40	<p>Megan: Jenny, can you see Greg down the end? Wasn't he a lovely fellow? Going round the corner. Jenny, can you see the cows? Happy cows!  Jenny: I can see the cows.  Megan: Is it a really good clear view through that front camera now?  Jenny: Yes.  Megan: Technician soldered a new USB connection onto that front camera so finally we have it fixed, it's taken a while but we ended up getting a new USB.  Technician: That being said, the front camera just stopped working, might have something to do with hitting the side.  Jenny: This is going to be tricky with the cow pat.  Megan: Yes! Did you like it as a bit of fun everyone? With the cow pat?</p>
16:33	<p>Megan: Jenny gave the cow pat such a wide berth that she ended up clipping the board on the far side.  Excellent driving as usual, Jenny.</p>
16:48	<p>Jenny: Thank you! (sounds very pleased with herself)  Megan: Technician, give us a smile (on webcam). Jenny, I can't wait for you to come down to Brisbane and you can finally get your hands on DCR14.</p>
17:12	<p>Megan: Jeremy, it's your turn. Are you right to go? Got the webpage loaded?  Jeremy: I'm already in, but I can't see the front camera.  Technician: Yeah, it's going to take a few minutes to reload.  Megan: Technician's just tinkering with it. It's reloading, Jeremy.  Jeremy: OK, I shall wait.  Megan: Yes, Donny, feel free to exit if you've got other things to do.  Technician: There we go, it should be working now.  Jeremy: No, not yet.</p>
17:49	<p>Megan: Everyone, if you've had your drive, feel free to go. I'll just remind you that we'll have another meeting next Friday. Then the following Wednesday, mark your diaries for Wednesday 10 December, for EV3 robot building here at BSDE. And Jenny, we'll link you in, for anyone who can't come onsite, we'll always link you in if you are off-site. Hands up if you think you can come into that day? John, Max, Peter? And Jenny, when you come down to Brisbane I promise you can touch the robots!</p>
18:45	<p>Jeremy: Anytime now, ready. I can't see the front camera.  Megan: Jeremy, what can you see?  Jeremy: Well the one on the left side, colours, the one on the right side, it's clear. The one down the middle, near the first front camera, the front camera is still loading.  Megan: Fantastic!  Jeremy: They're reloading.</p>
19:17	<p>Megan: Can you try driving and see if it'll let you move without that other camera working please?</p>
19:24	<p>Megan: Donny, I'd love you to come down to school to try this out.</p>
19:48	<p>Megan: Max, are you coming in because you were part of my First Lego League team and you were very good at it? Yes, Max, you can create a robot of your own design. I'm going to give you a box each. We have 6 of them! So you can create 6 amazing robots.  Megan: Peter, will you help with programming the robots that day?  Peter: Yep.  Megan: Thank you. Peter will help with programming. And, Technician I'll have you on hand that day too, I hope?  Technician: Yep.</p>
20:17	<p>Jeremy: Technician, what happens if I refresh the page? Would that work?  Technician: Yes, that's what you need to do.  Megan: Yes, Jeremy. Good idea. Yes, Jeremy.  Jeremy: I got it! I got it.  Technician: Yeah, I had a feeling it would work.</p>
20:38	<p>Jeremy: Front camera is on, I repeat, the front camera is on.  Megan: Mission Control ...  Jeremy: Yeah?  Megan: Mission Control, start driving the robot whenever you're ready!</p>
20:43	<p>John: I have something to ask Peter.  Megan: Go ahead, John.  John: Peter, if you're coming on the 10th, could you please teach me how to program?  Peter: Um, I don't actually know what program I'll be using yet, but I'll try.  John: Oh, OK. Well once you know how to program the EV3s, I'd like to learn how to program one.  Peter: Yes, OK.</p>

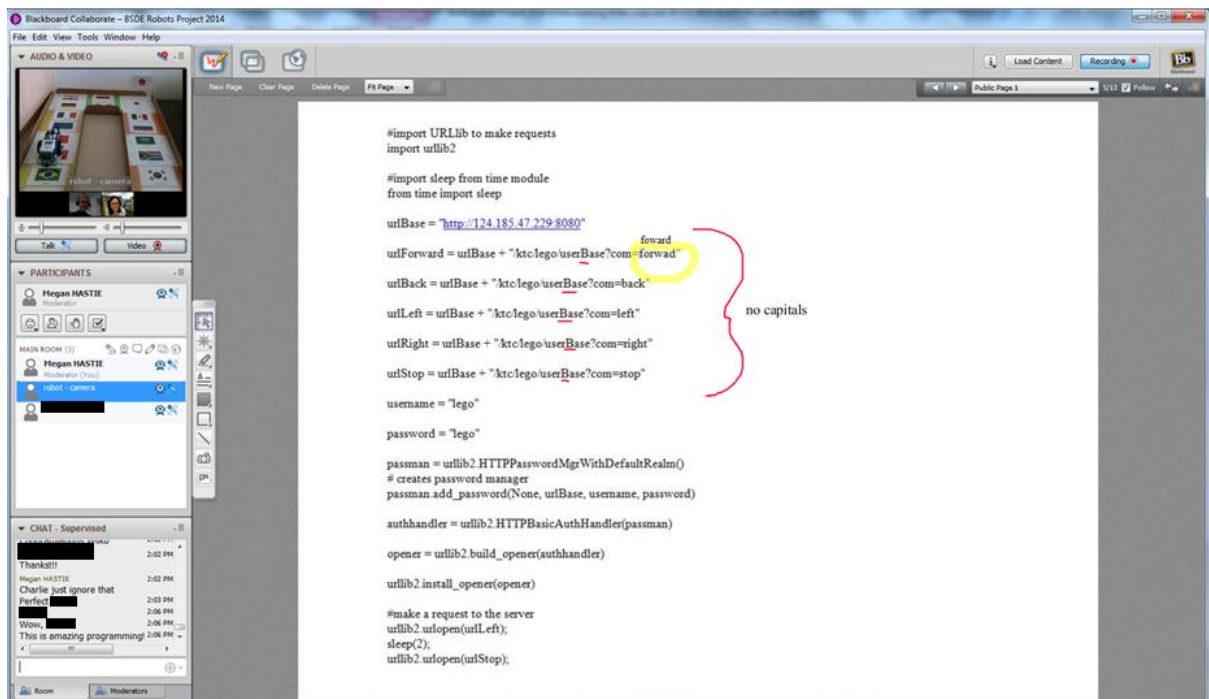
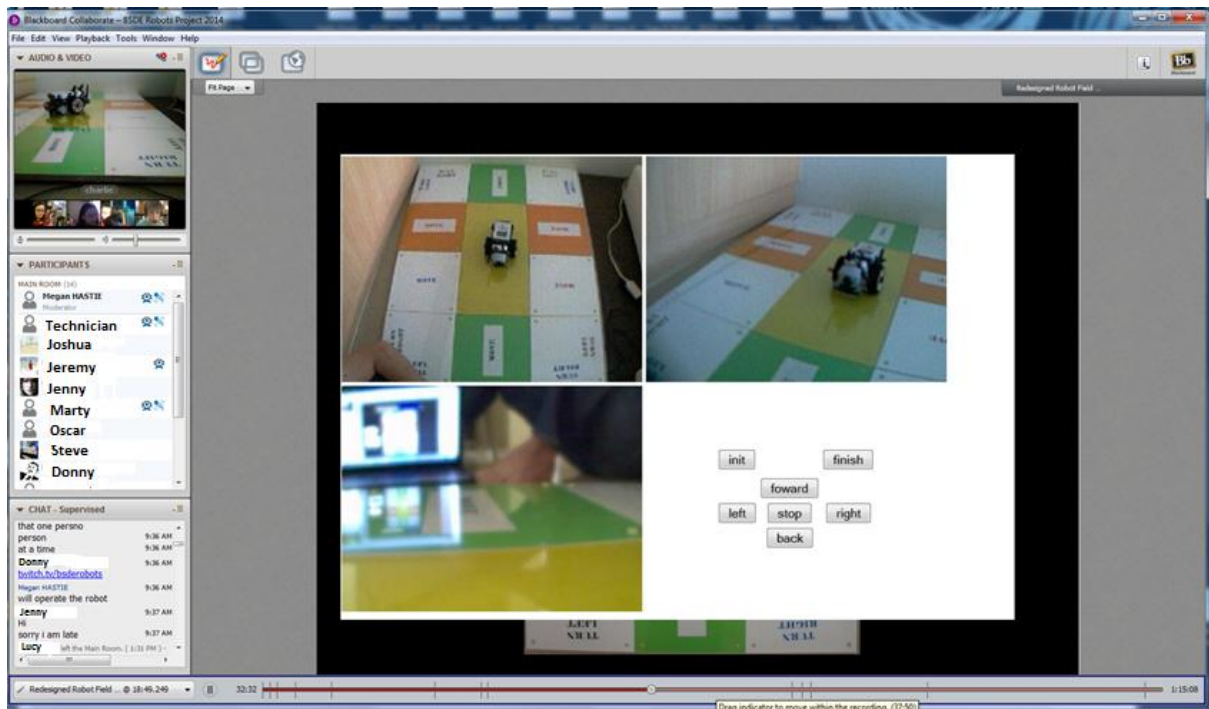
21:38	<p>Jeremy: I'm starting. Three, two, one. Now!</p> <p>Megan: There he goes. He gave us the countdown. You're loving this aren't you, Jeremy?</p> <p>Jeremy: Yes.</p>
21:44	<p>Megan: Let's just talk to Jeremy for a minute. Jeremy, can you see Greg at the end?</p> <p>Jeremy: Yes.</p> <p>Megan: And now can you see all his cows out in the field?</p> <p>Jeremy: Yes.</p> <p>Megan: And can you see the cows at the end and the mother and baby?</p> <p>Jeremy: Yes, I can see the cows, the mother, don't hit the baby, don't hit the baby!</p> <p>Megan: Don't scare the baby! This calf will be getting used to robots, because DCR14 is whizzing by, and it may grow up to be a milker and it might be getting used to seeing robots just like its mother.</p> <p>Jeremy: Aah. It's my worst nightmare the 'poo'.</p> <p>Megan: You have to position yourself very carefully, right. Sharp right turn. I think you've got the wheels in just the right spot. Look at this. He's giving that cow pat a wide berth.</p> <p>Jeremy: That was an accident hitting the horn.</p> <p>Megan: Have you tooted the horn yet? Technician, did you hear the horn.</p> <p>Technician: Yes, twice.</p> <p>Megan: Jeremy is showing off today.</p> <p>Jeremy: Woohoo!</p> <p>Megan: Jeremy is that the best driving you've ever done? I think it is.</p> <p>Jeremy: Yes, wait a minute.</p> <p>Megan: Oscar, just watch what you're doing with the chat. Use the chat responsibly.</p> <p>Jeremy: Wait a minute, what if DCR14 was actually a bull?</p>
23:38	<p>Megan: So, Oscar it's your turn. Are you right with the URL, Oscar? So, Jeremy you need to stop.</p> <p>Jeremy: OK.</p> <p>Megan: Back it up. Only one turn each.</p> <p>Jeremy: Yeah, I was just saying what if DCR14 was a bull.</p>
24:03	<p>Megan: Jenny's got the URL, lightning fingers, thanks Jenny, great support.</p> <p>Megan: Jeremy, you were being a bit mischievous there, your turn had ended, right? You needed to end your turn.</p> <p>Jeremy: Yes.</p> <p>Megan: Jeremy, you need to stop.</p>
24:27	<p>Megan: John and Peter want to have a conversation. Over to you John and Peter.</p> <p>Peter: Megan, can I just paste up a link. It's the link to the Lego site with the building instructions for different sorts of robots.</p> <p>Megan: Thank you, you're most welcome to do that. I didn't put any research pages in today. I thought today we'd just focus on remote operation of DCR14, which is the best fun, right? You agree?</p> <p>Oscar: Yeah.</p> <p>Megan: Peter, you could also put that in the chat-room so everyone can access it?</p> <p>Peter: Those are the 5 types (EV3 robots).</p> <p>Megan: Thank you Peter. Ahh, so these are the basic designs?</p> <p>Megan: Oscar, you're doing very well.</p> <p>Peter: From Lego. On the website, you can actually find more that people have sent to Lego.</p> <p>Megan: Oscar, can you see the cows.</p> <p>Oscar: Yeah.</p> <p>Peter: I like the EV3RSTORM one</p> <p>Megan: Good. Peter, point to your favourite please. Why do you like it the best? The Storm. It looks almost humanoid, I think, that's probably one of the things?</p> <p>Peter: Yeah.</p> <p>Megan: Now, I hear the Japanese have a new robot that's living in people's homes, called 'Pepper'. Has anyone heard of 'Pepper'? Can someone find an image please of 'Pepper,' because it's been in the news lately?</p>
25:09	<p>Megan: Oscar, you've done brilliantly, great driving, Oscar.</p> <p>Megan: Oscar, tell us how the controls are feeling?</p> <p>Oscar: They're a lot more 'smoother' and it's easier to control DCR14.</p> <p>Megan: Fantastic. Technician did you hear that?</p> <p>Technician: Ah, yes.</p> <p>Megan: Oscar is saying the mouse button innovation is easier to control, and more direct, Oscar?</p> <p>Oscar: Smoother and easier to control DCR14.</p> <p>Megan: Fantastic. Great research data, Oscar, for us. I greatly appreciate that.</p>
27:50	<p>Megan: There's 'Pepper' (pasted on whiteboard). Who found that? Can you find out what 'Pepper' can do? Can anyone find a bit of information. Peter, over to you. Look at how humanoid 'Pepper' looks. Look at the fingers and joints. This is getting seriously human-looking isn't it? It's changing to a whole new way of life for all of us. We will be living and working with robots in your lifetime. What you're doing by being in this project, you have got a head start on a lot of other people, you are learning about robots and learning to program them, and I think you will be our robotic Engineers of the future! I'm very proud of you.</p>
29:12	<p>Megan: OK Oscar, that was great. Joshua, it's your turn to drive.</p> <p>Megan: (To other students who have already driven the robots). If you've got other jobs to do, you can exit the session, or you're welcome to stay and watch the remote operation and share research ideas here, but if you have other school work to complete feel free to exit, or if you've had enough, feel free to go.</p>
29:30	<p>Marty: (in chat-room) says it also helps if you know someone who knows about Engineering.</p> <p>Megan: Yes, Marty, you're right. Marty, spot on. And how lucky am I and our group to have a Mechatronics Engineer</p>



	<p>named Technician giving us his time and expertise, and you know what I think that Technician really loves it too, Technician you love it?</p> <p>Technician: Sure.</p> <p>Megan: Technician, it's not work for you, right? More like play? Technician loves this too.</p> <p>Technician: Sure. I think someone's trying to get out of paying me! You shouldn't be paying me for it if you're enjoying it (jokes).</p>
30:33	<p>Megan: Joshua, let's see what we can do to help you. Oscar, have you clicked out?</p> <p>Oscar: Yes, I did.</p> <p>Megan: Thanks Oscar, I thought you would have.</p>
30:40	<p>Megan: Joshua, how are you going? It could be your connection up on the mountain?</p>
31:20	<p>Megan: Now look at this fantastic information (on whiteboard). Who found this information on 'Pepper'? Was that you Peter or Marty? Marty confirms (in chat-room) that he pasted pics of 'Pepper' on whiteboard.</p> <p>Megan: Now Marty, what do you think of 'Pepper'. Look at the ears. Good design?</p> <p>Megan: Yes, Marty, go ahead.</p> <p>Megan: What might the front screen on 'Pepper' be used for?</p> <p>Max: comment (in chat-room) that 'Pepper' can bow.</p> <p>Megan: Max, yes. 'Pepper' would bow from the waist like Japanese people do, it's their way of being polite and we love that don't we? Polite, respectful behaviour, is what we value also.</p> <p>Jenny: comments (in chat-room) on 'Pepper's' eyes, describes them as 'sparkly'.</p> <p>Megan: Yes, Jenny. 'Pepper's' eyes are sparkly.</p> <p>Megan: Can anyone find a YouTube clip of 'Pepper' interacting with humans?</p>
33:04	<p>Megan: Joshua, what are you seeing? I think you may have a connection?</p> <p>Joshua: Whenever I put the URL in, it says unable to connect.</p> <p>Megan: Do you want to try refreshing?</p> <p>Technician: Check the URL (then pastes URL in chat-room again)</p> <p>Megan: Try pasting that again, Joshua.</p>
33:49	<p>Megan: Peter, do you have new code to test today?</p> <p>Peter: No.</p> <p>Megan: You can still have a drive. You could try your old code if you like.</p>
34:26	<p>Megan: Joshua, how are you going? Keep us updated.</p> <p>Joshua: I got it working</p> <p>Megan: Oh, good! How are you going, Joshua? How does it feel?</p> <p>Joshua: I haven't started yet.</p> <p>Megan: Any luck? Keep us informed please.</p> <p>Technician: Remember to hold the mouse button down.</p> <p>Megan: There is goes. Well done. Joshua, can you see Greg yet? Back up, back up might be the best way to get out of that. Back up, Joshua.</p> <p>Joshua: (inaudible)</p> <p>Megan: Back up a bit and go down to see Greg and Dyna.</p> <p>Joshua: Sorry, it's very 'glitchy' with my computer.</p> <p>Technician: You need to go around the corner. Back up a bit, then forward, a bit more, there you go.</p>
36:14	<p>Megan: Now can you see the cows, Joshua? Do you have cows like this where you live near Maleny, Joshua?</p> <p>Joshua: Um, there's lots.</p> <p>Megan: Because you're near a dairy area, aren't you, up near Maleny. What was that, Technician?</p> <p>Technician: He's just scraping along the barriers.</p> <p>Megan: Joshua, try to go down the middle of the field so you don't get caught up on the sides. Joshua, aim DCR14 towards the middle of the tiles, so you don't get caught on the sides.</p>
37:04	<p>Jeremy exists session.</p> <p>Megan: OK, Jeremy, see you! You did great work today. Joshua driving, then John, Peter and Max. Marty and Jenny, feel free to exit if you've got other things to do.</p>
37:20	<p>Joshua: My connection is 'glitching-out' (audio inaudible)</p> <p>Megan: I can't hear you, Joshua. Have you got a headset on?</p> <p>Joshua: Is this better?</p> <p>Megan: Yes, that is a bit better.</p> <p>Joshua: The reason I'm having so much trouble is because my computer is 'glitching'.</p> <p>Megan: I think it might be your connection, Joshua. So Technician, can you just move it off the side? And it could be to do with the storm. With yesterday's bad storm?</p> <p>Joshua: I've got the storm right now.</p> <p>Megan: Oh, right, you've got the storm overhead.</p> <p>Max: suggests (in chat-room) to Joshua to back up the robot.</p> <p>Megan: Marty is getting it too. Thanks Max. Joshua, are you controlling it now?</p> <p>Joshua: I'm not controlling. Well part of the time I wasn't controlling.</p> <p>Megan: Is someone else controlling? Only one person at a time. Joshua, are you controlling now?</p> <p>Joshua: Yes, right now I am.</p> <p>Megan: Look at that, precision driving. No cow poo on the wheels. Well done, Joshua. Great driving, Joshua. And you managed very well considering your connection is a bit 'glitchy'. Well done.</p>
39:46	<p>Megan: OK. How many times have you operated our robot remotely now, Joshua?</p> <p>Joshua: Four times.</p> <p>Megan: John, over to you. John, your turn.</p> <p>Megan: Joshua, I think you haven't had as much practise as other people and you're doing really well. What do you like</p>

	<p>about it? Can you give us a bit of data?</p> <p>Joshua: Well, I like that I'm actually in my house and controlling it from my house, and controlling the robot remotely.</p> <p>Megan: What's so good about that, Joshua? Why is that so good? John, whenever you're ready.</p> <p>Technician: the rain has just started.</p> <p>John: Three, two, one. Now!</p> <p>Megan: He's off, he just counted down.</p> <p>Joshua: (in chat-room) say it sounds exciting</p> <p>Megan: Joshua, does it 'feel' exciting? To be operating something remotely like that.</p> <p>Joshua: no reply</p> <p>Megan: Let's see what John's seeing.</p>
41:14	<p>Megan: Let's just see what John can see.</p> <p>John: I can see Technician as well, through front camera, I can see him.</p> <p>Megan: Technician give him a wave to John,</p> <p>John: Hi (to Technician), I've got to position him correctly. I can see the white chair, the floor, the track.</p> <p>Megan: And past the cow pat now. Concentrate. Concentrate on that cow pat. Step lightly!</p> <p>John: I just did.</p> <p>Megan: Oh, you've done very well. Excellent driving. It seems the more practice we get the better we are at driving. Like anything, like learning to play a musical instrument, like learning handwriting, learning to drive a car, all of those things. So you are becoming expert remote control operators. Max, over to you.</p>
43:01	<p>Megan: Alright, there are our interesting EV3 combinations. There's 'Pepper' (on whiteboard).</p> <p>Megan: OK. There goes Max driving. There's Greg. Max, can you see all the cows?</p> <p>Max: confirms (in chat-room) that he can see the cows.</p> <p>Megan: There's the mother and calf, beautiful. Now down the straight. See how fast you can go, Max.</p> <p>Megan: Technician, is it raining?</p> <p>Technician: Yeah, heavily.</p> <p>Megan: I could hear it in the background.</p> <p>Megan: Max, you're doing really but just watch your step because we don't want any of the 'you know what' on the wheels. You know it's not real don't you, everyone? You all know it's pretend.</p> <p>Peter: He's stuck.</p> <p>Megan: It's just a picture, right, not the real thing.</p> <p>Peter: We'd be in real trouble if it was.</p> <p>Megan: Max, great driving. Look, he's got it backed-up. He's being such a courteous person, he's got it backed up for you, Peter.</p>
45:15	<p>Megan: Max, are you finding the mouse button control much better? Tell us about it.</p> <p>Max: Yes.</p> <p>Megan: Max, did you toot the horn?</p> <p>Max: confirms he tooted the horn.</p> <p>Megan: Technician did you hear the horn when Max tooted it?</p> <p>Technician: Yes.</p> <p>Max: I could hear the horn too.</p> <p>Megan: You could hear it too, Max, good hearing.</p>
46:06	<p>Peter: Can I paste another picture on the whiteboard?</p> <p>Megan: Peter, at the end, let's get you driving the robot first. Peter wants to do everything at once!</p> <p>There's Greg. We'll go up to see him on his farm next year, for an excursion.</p>
46:38	<p>Peter: I can see lots of cows.</p> <p>Megan: Technician isn't this (the dairy theme) working well, with the pictures on the whiteboard and they can see them out of the camera too. Everyone, can you think of any other themes for the Robot Field?</p> <p>Peter: Mars, a Martian landscape.</p> <p>Max: A tunnel.</p> <p>Megan: I had thought of a tunnel, of making a milking shed for today but I ran out of time.</p> <p>Megan: This is excellent. We've had 9 operators today. Fantastic. So, let's build a tunnel for DCR14 and the Mars idea is good too.</p>
48:13	Megan: Peter, do you want to blow the horn?
48:31	We spot Technician reading an e-book on his Kindle on the webcam. Jenny jokes that I can keep an eye on Technician at home and we agree that there are no secrets when we have a webcam.
48:49	Peter: giggling (as he toots the horn).
49:11	<p>Megan: Max and Jenny, which EV3 robot designs do you like? (from those on the whiteboard)</p> <p>Jenny: I like the EV3RSTORM, like Peter.</p> <p>Max: I have three.</p> <p>Megan: Max, you're just going to be a bit greedy and have three, right? (Max points to 3 robot designs on whiteboard, including the EV3RSTORM).</p> <p>Peter: Everyone likes EV3RSTORM, discusses possible EV3 robot designs. I've just got another idea for Technician. Right now when you turn one wheel goes forward and one goes backwards (on EV3 design). Is it possible to take a wheel off,</p> <p>Technician: Yes you can do that.</p> <p>Peter: Yes, add extra buttons. Arc right, arc left, so one wheel only will spin.</p> <p>Technician: Yeah, I'll take a look at it.</p>
51:09	Megan: Everyone, keep next Friday in mind. We'll have another meeting. And look, DCR14 is saying it's December already. Any questions or comments? OK, everyone, let's go.
51:26	Megan: Thanks for your participation. Bye.
51:40	Recording ended.

## Video recording screen-shots



## Appendix D

### Student blog samples

#### Blog 1

##### DCR14

*Posted by Jenny at Friday, 21 November 2014 12:20:19 PM GMT+10:00*

***Dear Robot Project Team and Megan,  
I find it easier with just holding down the buttons,  
to control DCR14 on the track, and I also like to say,  
it has been a lot of fun controlling DCR14 remotely :)***

[Comment](#)

#### Blog 2

##### Driving DCR14

*Posted by Jenny at Friday, 14 November 2014 9:07:32 AM GMT+10:00*

***Hello Everyone,  
I would just like to say, I found it easier to drive DCR14 with  
just holding down the button and not having to click it all the time.***

[Comment](#)

#### Blog 3

##### Happy To Be Driving DCR14 Again

*Posted by Jenny at Wednesday, 29 October 2014 11:57:46 AM GMT+10:00*

***It is so good to be driving DCR14 again and it has a 1 1/2 second delay when i click  
"forward" but overall i enjoyed it***

[Comments: 1](#) [Comment](#)

- *Lucy said...*

Tuesday, 4 November 2014 9:58:00 PM GMT+10:00

ooh ok then, that's good!

#### Blog 4

##### I am So Excited To Work With DCR14!!

*Posted by Jenny at Wednesday, 8 October 2014 8:34:03 AM GMT+10:00*

***I am soo happy to be back at school and to be working with DCR14***

[Comments: 2](#) [Comment](#)

- *Pierre said...*

Wednesday, 8 October 2014 9:04:58 AM GMT+10:00

me too

**My Idea**

Posted by Jenny at Thursday, 11 September 2014 11:13:31 AM GMT+10:00

**Hello Everybody,**  
**I Was Thinking That Maybe We Could Make A Rocky Terrain, But Not Too**  
**Rocky.**  
**Then Maybe We Can Have A little Hill Climb.**  
**From,**  
**Jenny**

[Comments: 10](#) [Comment](#)

• *Pierre said...*

Thursday, 11 September 2014 11:39:26 AM GMT+10:00

Sounds Great

• *Jenny said...*

Monday, 15 September 2014 3:19:19 PM GMT+10:00

Well Then We Can See If DCR14 Is Able To Go On Rocky Terrains

• *Debbie said...*

Wednesday, 17 September 2014 8:45:51 AM GMT+10:00

that sounds AWESOME Jenny!

• *Jenny said...*

Wednesday, 17 September 2014 12:51:31 PM GMT+10:00

I Love Your Ideas Pierre They Are Really Mind Blowing!!!

• *Pierre said...*

Thursday, 18 September 2014 9:19:02 AM GMT+10:00

Thx Jenny :D

### Controlling DCR14 Remotely

Posted by Jenny at Wednesday, 10 September 2014 8:58:27 AM GMT+10:00

Hello Everyone.

I Would Just Like To Comment On Controlling DCR14 Remotely

I Think It Was Absolutely Fun! I Hope Everyone Gets The Same Enjoyment Of Controlling Him

I Just Love The Ideas That Everyone Has Come Up With.

I Hope That Everyone Has A GREAT Time With DCR14

From.

Jenny

[Comments: 6](#) [Comment](#)

• *Pierre said...*

Wednesday, 10 September 2014 9:18:06 AM GMT+10:00

I agree driving DCR14 remotely is great fun! :)

• *Megan Hastie said...*

Wednesday, 10 September 2014 10:19:53 AM GMT+10:00

Wonderful! I love to hear these comments and thanks Jenny for starting this thread in the Blog. Your participation from a remote location is so important in our research, Jenny, as you're proving that 'distance' is no barrier to learning about robots - and to driving a robot! Thanks so much.

• *Jenny said...*

Wednesday, 10 September 2014 12:55:28 PM GMT+10:00

It's My Pleasure Megan

• *Lucy said...*

Wednesday, 10 September 2014 2:51:58 PM GMT+10:00

I love doing things like this. . .  
It's so much fun!

• *Debbie said...*

Thursday, 11 September 2014 8:49:49 AM GMT+10:00

I agree with Lucy

• *Jenny said...*

Thursday, 11 September 2014 10:35:48 AM GMT+10:00

It's Very Exciting That We Can Control DCR14 Remotely and Many Thanks To the Japanese Professor's For Getting Us The NXT Lego Robot

### What If

Posted by Jenny at Friday, 22 August 2014 9:16:52 AM GMT+10:00

*What if we could make DCR14 High, so we put in a higher suspension and then it would be easier to pick him up and see underneath him, in case of a problem occurs*

[Comments: 3](#) [Comment](#)

• *Debbie said...*

Monday, 25 August 2014 10:25:23 AM GMT+10:00

sounds great Jenny

• *Pierre said...*

Monday, 25 August 2014 10:33:06 AM GMT+10:00

That's a really good idea

• *Jenny said...*

Tuesday, 2 September 2014 12:19:56 PM GMT+10:00

Thx Guys :)

**Appendix E**  
**Examples of Information and Consent forms used to undertake research**

**Information for Student participants and Parents/Caregivers**

**Invitation to participate in a research study based on  
the BSDE Robots Project 2014**

I, Megan Hastie, Experienced Senior Teacher at Brisbane School of Distance Education, would like to invite your child to be involved in this research study:

***Skilling Students in Digital Technologies  
using Long-Distance Controlled Robots over the Internet.***

The study is being conducted in partial fulfilment of a **Doctorate of Education degree for Megan Hastie** under the supervision of:

1. Dr Andrew Fluck, University of Tasmania
2. Chair Prof Nian-Shing Chen, National Sun Yat-Sen University, Taiwan

The purpose of this study is to ***understand the educational values for school students of engagement with robots from a distance using remote control.***

Students at Brisbane School of Distance Education (BSDE), in collaboration with international institutions, will participate in the research and development of an emerging digital technology – a Long-Distance Controlled Robot (LDCR) system.

Students will develop knowledge, understanding and skills in robotics using the LDCR.

Student engagement with LDCR technologies will enable them to make informed, ethical and sustainable decisions about technologies for preferred futures including personal health and wellbeing, recreation, everyday life, the world of work and enterprise, and the environment.

Research findings from the long-distance controlled robot system program can be extrapolated to other schools in Australia and shared in international forums.

The data from this study will indicate whether emerging technologies such as the LDCR system can be used to teach the new Australian curriculum: Technology, *Digital Technologies*, given the need in Australia for enterprising individuals who can make discerning decisions about the development and use of technologies (ACARA, 2014).

**Why has my child been invited to participate?**

Your child has been invited to participate in this study because they volunteered to participate in the ***BSDE Robots Project 2014.***



Your child will be part of an experimental volunteer group of approximately 30 students who are:

- currently enrolled at Brisbane School of Distance Education in Year 6 and Year 7
- 9-12 years of age
- interested in educational robots

Please be assured that your child's involvement is voluntary, that there are no consequences if you decide not to participate, and that this will not affect, for example, your child's relationship with Brisbane School of Distance Education.

### **What will your child be asked to do?**

Your child will be asked to participate in co-curricular activities organised by Megan Hastie that are related to the ***BSDE Robots Project 2014***.

These will include:

- **on-site activities at school** in which your child can interact directly with the Lego NXT robot
- **off-site activities via the Internet** including remote control of the Lego NXT robot
- **online meetings** with other students, teachers and experts in robotics

This study has three parts:

#### **Part 1**

Your child will be asked to **complete two surveys** related to robots which will take about 10 minutes each:

- surveys will be conducted at the beginning and end of the research study
- survey responses will be de-identified (your answers will be confidential)
- survey responses from you and other students will be analysed and collated to provide the research data

#### **Part 2**

Your child will be asked to **contribute to a BLOG** about robots:

- the BLOG will be on the Year 6 Blackboard page
- the BLOG will run throughout the research study
- the BLOG responses from your child and other students will be collated as research data

#### **Part 3**

Your child will be **observed operating the robot using the LDCR system** with information recorded by video/still camera to determine:

- frequency of robot operation
- duration of robot operation
- the types of manoeuvres performed by the robot

### **Are there any possible benefits from participation in this study?**

While there are no intended benefits to the participants in this study, there is a likelihood that your child's understanding of digital technologies may improve as a result of their involvement in the robot program.

The wider benefits of this study extend to the understanding of emerging technologies such as educational robotics. This understanding, while not being comprehensive at this stage, may result in recommendations for improvements in the processes of teaching digital technologies in both schools of distance education and in mainstream schools.

### **Are there any possible risks from your child's participation in this study?**

The physical activity involved in the survey is low risk and the surveys are not expected to pose any risk or threat to your child.

Your child's answers will be based on your experience and perceptions of long-distance remote controlled robots.

The questions in the surveys will be both multiple-choice and open-ended.  
Your child's answers will be confidential.

### **What if my child changes their mind during or after the study?**

- Your child is free to withdraw at any time, and can do so without providing an explanation.
- If your child chooses to withdraw from this study, I will ask your permission to retain any data that has been collected until December 2014. You are free to decline this request.
- Data that have already been processed will not be able to be withdrawn.
- No observational data will be retained from students who withdraw from the study.

### **What will happen to the information when this study is over?**

- The data from this study that is kept will not bear the names of participants or be identifiable after the completion of the project.
- Sufficient information will be needed to match survey results but, once all data are collected, names and means of identifying participants will be removed from the data and stored separately. For instance, the four digits that comprise 2014 + two random digits will be assigned.
- In accordance with the research requirements, research data will be kept for 5 years from the date of completion of the study.

### **How will the results of the study be published?**

- The study forms a part of the requirements for Doctorate of Education and, as such, findings will be presented at a number of forums for educational research.
- The thesis may or may not be published.
- Any participant who would like to learn of the results of the study can contact [mjhastie@postoffice.utas.edu.au](mailto:mjhastie@postoffice.utas.edu.au) for copies of any reports.
- No participant will be identifiable in the final report.
- Pseudonyms will be used in cases where a participant is referred to specifically.

## **What if I have questions about this study?**

If you have any questions about this study you may contact the following people:

Dr Andrew Fluck  
Senior Lecturer in Information Technology  
Department of Education  
University of Tasmania  
Locked Bag 1307, Launceston 7250  
Phone: 6324 3284  
Email: [Andrew.Fluck@utas.edu.au](mailto:Andrew.Fluck@utas.edu.au)

Megan Hastie  
Brisbane School of Distance Education  
2 Cavendish Road COORPAROO. Q 4100  
Phone: 07 37272747  
Email: [mhast5@eq.edu.au](mailto:mhast5@eq.edu.au)

Contact details for the Ethics Committee:

This study has been approved by the Tasmanian Social Sciences Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study, please contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479 or email [human.ethics@utas.edu.au](mailto:human.ethics@utas.edu.au).

The Executive Officer is the person nominated to receive complaints from research participants. Please quote ethics reference number [H14122].

**This information sheet is for you to keep. Your consent to be involved in the survey activity is implied by your completion of the survey form. Should you also wish to give your consent to be involved in the interview, complete the appropriate section on the Survey form. A written consent form will also need to be signed after you have been invited to participate in the interview.**

## Research Study - Consent Form for Students

Dear Students,

Thank you for your interest in for the **BSDE Robots Project 2014**.  
In this project we will learn about digital technologies, in particular, robots.



The project will include:

- on-site activities at school in which you can operate a Lego NXT robot: **DCR14**
- off-site activities using a Long-Distance Control Robot system to operate **DCR14**
- online meetings with other students, teachers and experts in robotics

During 2014, I'm conducting **research** on educational robots. I'd like you to help me!  
Your participation in the project will not affect your school grades.

For the research, if you agree to participate, you will be invited to complete **two Surveys** related to robots:

- The first survey will be in August, and the second survey will be in December
- Each survey has around 7 questions and will take about 10 minutes to complete
- Your name will be removed from the surveys
- Your answers will be confidential

You will also be asked to contribute to a **BLOG** about robots:

- The BLOG can be found on our Year 6 Blackboard site
- You can add comments and also delete your comments if you wish

You will be observed as you use the robot, and videos & photos may be taken to record your progress.

Please note that you can withdraw from the research at any time.

Your parent/care-giver must give consent also.

If you agree to be part of the research, please sign your name below:

<b>Student's name</b>	
<b>Signature</b>	<b>Date:</b> /08/2014

Thank you,

Megan Hastie  
Experienced Senior Teacher  
Brisbane School of Distance  
Education  
Phone: 37272747  
Email: [mhast5@eq.edu.au](mailto:mhast5@eq.edu.au)

## **Parental/Care-giver Consent Form for Surveys for Doctorate of Education research study**

1. I agree my child can take part in the research study named above.
2. I have read and understood the Information Sheet for this study.
3. The nature and possible effects of the study on my child have been explained to me.
4. I understand that the study involves my child participating in two surveys and contributing to a blog and being observed when operating the robot. Each survey will take approximately 10 minutes to complete. Videos and photographs may be taken to record progress.
5. I understand that in no way does this affect my child's grades.
6. I understand that participation involves no foreseeable risk to my child.
7. I understand that all research data will be securely stored on the University of Tasmania premises for five years from the publication of the study results, and will then be destroyed.
8. Any questions that I have asked have been answered to my satisfaction.
9. I understand that the researcher(s) will maintain confidentiality and that any information my child supplies to the researcher(s) will be used only for the purposes of the research.
10. I understand that the results of the study will be published so that my child cannot be identified as a participant.
11. I understand that my child's participation is voluntary and that I may withdraw my child at any time without any effect.
12. I understand that I will be able to withdraw any unprocessed data until December 2014.

**Student's name:** \_\_\_\_\_

**Parent/Caregiver's name:** \_\_\_\_\_

**Parent/Caregiver's signature:** \_\_\_\_\_

**Date:** /08/2014

# Information for Student Participants

Dear (Student's name),

You are invited to participate in a research study that I'm conducting.

The study is based on the **BSDE Robots Project 2014**.

The study is called:

## ***Skilling Students in Digital Technologies using Long-Distance Controlled Robots over the Internet.***

I want to find out how students like you learn about digital technologies as you operate a robot using remote control.

You have been invited to participate in this study because you volunteered to participate in the **BSDE Robots Project 2014**.

### **What will you be asked to do?**

You will be asked to participate in **activities** such as:

- activities at school where you can operate the Lego NXT robot
- activities via the Internet using remote control to operate the robot
- online meetings with our team and experts in robotics

You will be asked to **complete two surveys** related to robots.  
These will take about **10 minutes** to complete. Your answers will be **confidential**.

You will be asked to **contribute to a BLOG** on the Year 6 Blackboard site.

You will be **observed** operating the robot using the LDCR system.  
Information will be recorded by video/still camera to measure:

- how often you operate the robot
- how long you operate the robot
- the types of manoeuvres you get the robot to perform

You will **NOT BE ASSESSED**.

There are **NO EXPECTED RISKS** from your participation in this study.

If at any time you **decide not to continue** in the research project, that's OK!

If you have any questions about this study you may contact the following people:

Dr Andrew Fluck  
Senior Lecturer in Information Technology  
Department of Education  
University of Tasmania  
Locked Bag 1307, Launceston 7250  
Phone: 6324 3284  
Email: [Andrew.Fluck@utas.edu.au](mailto:Andrew.Fluck@utas.edu.au)

Megan Hastie  
Brisbane School of Distance Education  
2 Cavendish Road COORPAROO. Q 4100  
Phone: 07 37272747  
Email: [mhast5@eq.edu.au](mailto:mhast5@eq.edu.au)

Contact details for the Ethics Committee:

This study has been approved by the Tasmanian Social Sciences Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study, please contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479 or email [human.ethics@utas.edu.au](mailto:human.ethics@utas.edu.au).

The Executive Officer is the person nominated to receive complaints from research participants. Please quote ethics reference number H14122.

**This information sheet is for you to keep.**

**Thank you!**

Megan Hastie  
Experienced Senior Teacher  
Brisbane School of Distance Education